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A METHOD FOR EVALUATING THE EFFECTIVENESS OF IMPROVING PUBLIC TRANSPORT SERVICES, PARKING FEE POLICIES, AND PARK-AND-RIDE FACILITIES IN ORDER TO ENCOURAGE THE USE OF PUBLIC TRANSPORT

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Abstract. Enhancing the quality of public transport services, implementing effective parking fee policies, and developing park-and-ride facilities are common solutions that urban planners and city governments apply to encourage public transport use. However, estimating the impact of these measures on increasing public transport usage during the solution design process is challenging. This article proposes an approach to assess the effects of these measures in the solution design process, which policymakers or city governments can apply to formulate suitable policies and feasible measures aligned with the local context. The approach begins with a survey on travel behaviour, followed by formulating a mode choice model to assess the sensitivity of the mode share to factors affecting mode choice. This approach is applied to Da Lat city, and the research results indicate how to enhance public transport services, determine appropriate parking fee levels, and establish park-and-ride facilities to achieve a public transport share of 5%, 10%, 15%, or higher. One of the main research results shows that the Park and Ride solution is feasible. Additionally, to achieve a growth rate of public transport volume up to 10%, it is necessary to improve public transport quality services combined with an increase in car parking fees in the downtown area.

Keywords: public transport quality, parking fee policies, park and ride (PnR), Da Lat City

1. INTRODUCTION

Da Lat City is a popular tourist destination renowned for its rich indigenous culture, urban heritage, and landscape architecture [1]. However, rapid economic development, population growth, and the increasing ownership of private vehicles, coupled with the growth of tourism, have led to traffic congestion in the city. This issue is not only prevalent during peak tourism seasons but also on regular days. Moreover, the ownership rate of motorcycles and private cars in Da Lat City is comparable to the motorization level in major cities such as Hanoi and Ho Chi Minh City. Over 90% of all trips are made using private vehicles, while buses account for only 1-2% [2]. The number of tourists visiting Da Lat - Lam Dong increases every year, with domestic tourists constituting about 90% [1]. The primary mode of transport for domestic tourists is private cars, contributing to frequent congestion on major routes and intersections.

One of the top priorities for Da Lat, is to ensure a smooth, convenient, and flexible transportation system with sufficient infrastructure capacity [2]. Due to the increasing traffic congestion in recent years, in-depth research is necessary to analyse and assess the situation, identify its causes, and propose strategic solutions. Limiting the use of private motorized vehicles and promoting non-motorized transportation is considered a sustainable long-term solution for urban areas. Therefore, the article focuses on studying the impact of several solutions, including improving the quality of public transport services, implementing parking management policies and fees, and introducing Park and Ride systems, on promoting the use of public transport by residents and tourists in Da Lat. While these solutions have been effective in many cities, it is crucial to study how they will impact a unique mountain city dominated by motorcycles like Da Lat. The results of this study will contribute to the city's efforts in formulating plans, solutions, and policies to encourage the use of public transport and alleviate traffic congestion in Da Lat City.

The article is divided into five parts: 1) Introduction and overview of the research issue; 2) Literature review; 3) Methodology and data collection; 4) The main results, including the mode choice model and the impact of improving the quality of public transport, parking fees, and Park and Ride on public transport share; 5) Conclusion and recommendations.

2. LITERATURE REVIEW

Some existing research has shown that car ownership is influenced by the service levels in the public transport system, resulting in additional benefits from improving public transport. One study by Holmgren et al. explored the relationship between public transport quality and car ownership, considering the broader benefits that may arise from improvements in public transportation services. The study involved quantitative analysis to assess the correlation between public transport quality enhancements and car ownership decisions, providing insights into the potential behavioral shifts resulting from improved service quality [3]. Another study by Chang et al. conducted a study in Kaohsiung City, Taiwan, to examine the effects of enhancing public transport services on modal shift behavior. The study included surveys, data analysis, and statistical modeling to evaluate the changes in modal shift patterns following improvements in public transport quality. By analyzing modal shift behaviors, the research aimed to quantify the impact of service quality enhancements on mode choice preferences. The research highlighted the significance of service enhancements in encouraging shifts towards sustainable transportation modes [4]. Furthermore, Rojo et al. investigated the relationship between service quality and the demand for inter-urban buses,

focusing on the practical implications for transportation policy and practice [5]. The study involved data collection, econometric modeling, and demand analysis to ascertain the influence of service quality improvements on passenger demand for inter-urban bus services. By examining the relationship between service quality and demand, the study provided valuable insights into the factors driving passenger choices and mode preferences [5].

Travelers responded to parking policies primarily by shifting parking locations rather than switching travel modes. While some papers suggest that parking policies can have a significant impact on the sustainability of urban transport systems and the use of public transport. One study by Petraki et al. found that parking charging policies can be a key tool for sustainable mobility, but public acceptability is an important precondition for their success [9]. Another study by Tercan investigated the effect of residential parking policy derogations on the sustainability of streets in Gaziantep, Turkey. The study found that parking policies can have a significant impact on the sustainability of streets and that the availability of public transport is an important factor in their success [10]. In addition, Syahputra et al. analyzed the implementation of parking service retribution policy in Sukabumi City, Indonesia. The study found that parking service charges can generate revenue for the local government and encourage the use of public transport [11]. Overall, these studies suggest that parking fee policies can be an effective tool for increasing public transport share and promoting sustainable urban transport systems. However, their effectiveness depends on factors such as public acceptability, availability of public transport, and revenue generation.

There is only a partial understanding among local authorities of the effectiveness with which park-and-ride addresses a range of objectives in practice. Key travel behavioural findings indicate that only a portion of park-and-ride users' car trips are shortened. While, some studies suggest that P&R facilities can have a positive impact on the increase in public transport share. One study by Kimpton et al. delved into parking behavior and the role of park 'n' ride facilities in encouraging multimodalism in Brisbane. The study included surveys, behavioral analysis, and urban planning considerations to understand how PnR systems can facilitate mode shifts towards sustainable transportation options, contributing to the urban landscape [6]. Another study by Lam et al. explored the factors contributing to the success of park-and-ride schemes in Eastern Asia, offering insights into the unique considerations and strategies that can make PnR systems effective in this region. The study likely involved qualitative research methods, policy analysis, and case studies to identify key success factors for PnR implementation in Eastern Asia [7]. Besides, the study by Hamer analyzed the effectiveness of park-and-ride facilities as generators of public transport mode shift. The study employed statistical analysis, travel behavior surveys, and mode choice modeling to assess the impact of PnR systems on encouraging shifts towards more sustainable modes of transportation [8]. These studies collectively contribute to the understanding of the role of park-and-ride facilities in promoting public transport use. The results found that P&R facilities can play an important role in promoting public transport use, but their effectiveness depends on factors such as location, accessibility, and service quality.

In general, the studies describe the methods used to assess the effects of these measures during the planning process and solution formulation. Some existing studies utilize Revealed Preference (RP) and Stated Preference (SP) surveys to assess the effectiveness of the measures, while others use parking choice models and mode choice models. To address the complexity of the transport system, the method of system dynamics to simulate and predict the effects of policy implementation is also recommended. In this study, we propose a method

that combines the mode choice model evaluated by RP and SP surveys with a 4-step simulation model of the transportation system [12-13].

3. METHODOLOGY

A survey on travel demand (Revealed preference - RP) and mode choice behaviour (Stated Preference - SP) of residents and tourists in Da Lat City has been conducted, with a sample size of 270 residents and 270 tourists. The objective of the survey is to capture the characteristics of travel demand of residents and tourists, factors influencing on the mode choice behaviour of residents and tourists, and based on that, develop a mode choice function using the multi-logit model. The constructed mode choice model will be used to evaluate the impact of improving service quality, adjusting parking fees, and developing park-and-ride facilities on promoting the use of sustainable transport modes by residents and tourists in Da Lat City. Based on survey data, mode choice models for Da Lat citizens and tourists to Da Lat are evaluated. Transport modal choice set includes: MC, car, bus, and bicycle for citizens; MC, car, bus, bicycle, and coach for tourists in Da Lat; MC, plane, car, coach and coach + PnR + bus for tourists travelling to Da Lat. Various solution scenarios are proposed to assess the effects of the three measures. The simulation model of the Da Lat transportation system by the VISUM tool is also used to support the assessment of the effects of the three measures on traffic by applying the mode choice model.

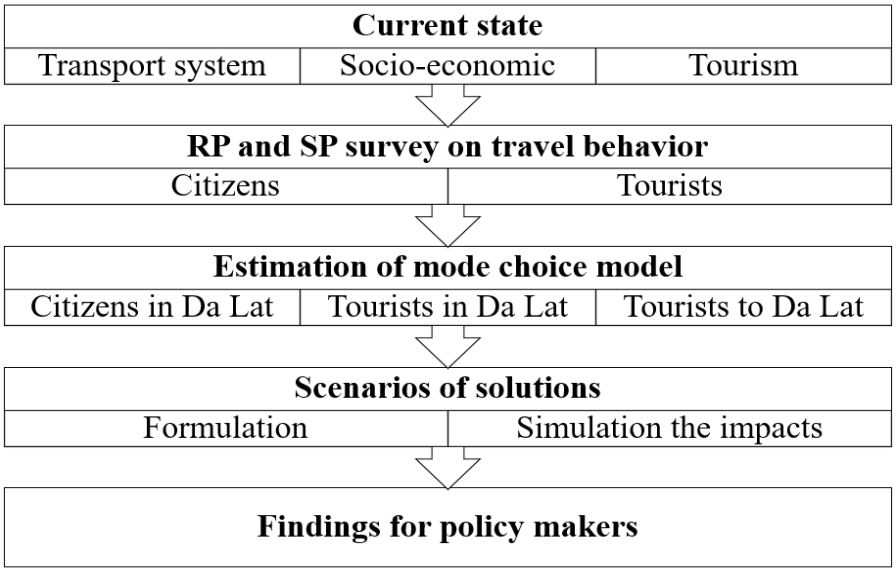

Figure 1 Studying framework.

The survey interview consists of the following content:

For residents: Part 1: Inquire about the demographic characteristics of the respondents, including gender, age, occupation, residential address, workplace address, vehicle ownership, income, average travel cost, and maximum monthly affordability; Part 2: Inquire about the characteristics of daily travel, including modes of transportation, number of trips taken in a day, and specific details of each trip (purpose, mode of transportation used, distance, cost); Part 3: Inquire about mode choice for hypothetical scenarios involving trip types, trip distances, travel time, cost, and mode of transportation (Table 1).

Table 1. An example of SP survey question on mode choice of residents and of tourists to Da Lat.

For daily trip of residents	Scenario 1		Scenario 2		Scenario 3		**For trip to Da Lat of tourists**	Scenario 1		Scenario 2	
	MC*	Car	Car	Bus	MC	Bus		Plane	Car	Coach	Car
Distance (km)	10	10	2	2	10	10	Distance (km)	500	500	300	300
Travel time (mn)	32	43	15	21	22	45	Travel time (mn)	2h 13 mn	12h 30 mn	7h 50 mn	5h 27 mn
Total travel cost (VND**)	17,000	40,000	8,000	5,000	22,000	15,000	Total travel cost (VND)	2,300,000	1,400,000	180,000	840,000
Mode choice	☐	☐	☐	☐	☐	☐	Mode choice	☐	☐	☐	☐

*MC: motorcycle; **VND or Vietnamese dong: Vietnam currency

For tourists: Part 1: Inquire about the demographic characteristics of the respondents, including gender, age, residential address, income, and modes of transportation used to travel to Da Lat; Part 2: Inquire about the characteristics of travel demand of tourists to and within Da Lat City, including the number of trips taken and specific details of each trip; Part 3: Inquire about the habits of using sustainable transport modes by tourists, their requirements for the quality of sustainable transport services, and their willingness to use and pay for sustainable transport services while traveling in Da Lat; Part 4: Inquire about mode choice for hypothetical scenarios involving trip types, trip distances, travel time, cost, and mode of transportation, including the option of park and ride.

The logit model has the following form:

$$P(i) = e^{U_i} / \sum_{j=1}^{n} e^{U_i} \quad (1)$$

Where, P(i) = Probability of mode i being chosen; uj = Utility of mode j; n = Number of modes

$$Ui = ai + \sum_{k=1}^{V} b_k * X_k^i \quad (2)$$

Where, Ui = Utility of mode i ; ai = Mode specific constant ; b_k = kth parameter ; X_k^i = kth model variable for mode i ; V = Number of model variables

4. RESULTS

4.1. Mode choice model

By performing correlation tests, we found that certain pairs of variables are highly correlated with each other. In the resident sample, the variables showing significant correlation include age and income, driving license and income, and income and driving license (Table 2). Additionally, in the tourist sample, we observed significant correlations between age and income, distance and time, and distance and cost for both trips to Da Lat and trips in Da Lat (Table 3 and 4).

Table 5 presents the calculated results of the multi-logit mode choice models for the residents of Da Lat City. The coefficients for time and cost variables for all modes are negative, which is reasonable because transportation participants tend to choose modes that are cheaper and faster. Bicycle and bus users are not influenced by the cost variable.

Motorcycle users are more sensitive to both the cost and the travel time variables compared to car users. Therefore, implementing parking control measures and parking fees in Da Lat City will affect the mode choices of motorcycle and car users. However, it will have a greater impact on motorcycle users than car users. The distance variable also influences the mode choice of Da Lat residents, except for the bicycle mode, which is not influenced by the distance variable. The coefficients of the distance variable are positive for all other modes, indicating that as the trip distance increases, residents tend to choose motorcycle, car, and bus modes over bicycles. Among the modes, the distance variable has the strongest impact on bus users. This means that as the trip distance increases, residents are more likely to choose the bus mode over cars and motorcycles.

Table 2 Correlation test of variables (residents in Da Lat).

		Age	**Gen.**	**Job**	**Dri.Lic.**	**Veh.O.**	**Inc.**	**Dis.**	**Time**	**Cost**
Age	PearsonCor.	1	-.085**	.142**	.232**	.030	**.527****	.027	.010	-.010
	Sig.(2-tailed)		.000	.000	.000	.190	.000	.238	.649	.660
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Gen.	PearsonCor.	-.085**	1	-.025	-.333**	.070**	-.231**	.007	.002	-.020
	Sig.(2-tailed)	.000		.273	.000	.002	.000	.749	.917	.389
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Job	PearsonCor.	.142**	-.025	1	-.100**	-.020	.051*	-.007	-.003	-.010
	Sig.(2-tailed)	.000	.273		.000	.390	.028	.765	.899	.669
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Dri.Lic.	PearsonCor.	.232**	-.333**	-.100**	1	.102**	**.549****	.000	-.008	-.004
	Sig.(2-tailed)	.000	.000	.000		.000	.000	.993	.727	.857
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Veh.O.	PearsonCor.	.030	.070**	-.020	.102**	1	.003	.040	.011	.012
	Sig.(2-tailed)	.190	.002	.390	.000		.899	.085	.630	.602
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Inc.	PearsonCor.	**.527****	-.231**	.051*	**.549****	.003	1	.020	.016	-.005
	Sig.(2-tailed)	.000	.000	.028	.000	.899		.390	.498	.818
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Dis.	PearsonCor.	.027	.007	-.007	.000	.040	.020	1	.269**	.321**
	Sig.(2-tailed)	.238	.749	.765	.993	.085	.390		.000	.000
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Time	PearsonCor.	.010	.002	-.003	-.008	.011	.016	.269**	1	-.243**
	Sig.(2-tailed)	.649	.917	.899	.727	.630	.498	.000		.000
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890
Cost	PearsonCor.	-.010	-.020	-.010	-.004	.012	-.005	.321**	-.243**	1
	Sig.(2-tailed)	.660	.389	.669	.857	.602	.818	.000	.000	
	N	1890	1890	1890	1890	1890	1890	1890	1890	1890

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Abbreviations: Gen. : gender; Dri.Lic. : driving license; Veh.O. : vehicle ownership; Inc.: income; Dis.: distance
PearsonCor. : Pearson correlation

Table 6 presents the results of calculating the multi-logit choice models for the tourist transportation modes in Da Lat city. The cost variable affects tourists' choices of car, bicycle, and bus, but no impact of cost is observed on the choices of motorcycle and public bus. Among them, the impact of cost on the choice of car is the lowest. Therefore, it can be predicted that if Da Lat city implements parking control measures and parking fees, it will affect tourists' car choices, but the level of impact will be low. While no impact of the travel time variable on tourists' car choices is observed, it does affect the choices of all other modes.

The negative coefficient of the travel time variable indicates that tourists tend to choose faster transportation modes. The model results also show that gender and income variables have an influence on tourists' mode choices. Males tend to choose cars more often, while females tend to choose buses and motorcycles more often. People with higher incomes tend to choose cars more often, while those with lower incomes tend to choose buses more often.

Table 3 Correlation test of variables (tourists to Da Lat).

		Age	**Gender**	**Income**	**Dis**	**Time**	**Cost**
Age	Pearson Correlation	1	-.046	**.520****	-.037	-.152**	.128**
	Sig. (2-tailed)		.282	.000	.389	.000	.003
	N	540	540	540	540	540	540
Gender	Pearson Correlation	-.046	1	-.107*	.012	-.005	.002
	Sig. (2-tailed)	.282		.013	.783	.913	.957
	N	540	540	540	540	540	540
Income	Pearson Correlation	**.520****	-.107*	1	-.008	-.198**	.251**
	Sig. (2-tailed)	.000	.013		.860	.000	.000
	N	540	540	540	540	540	540
Dis	Pearson Correlation	-.037	.012	-.008	1	**.608****	**.549****
	Sig. (2-tailed)	.389	.783	.860		.000	.000
	N	540	540	540	540	540	540
Time	Pearson Correlation	-.152**	-.005	-.198**	**.608****	1	-.182**
	Sig. (2-tailed)	.000	.913	.000	.000		.000
	N	540	540	540	540	540	540
Cost	Pearson Correlation	.128**	.002	.251**	**.549****	-.182**	1
	Sig. (2-tailed)	.003	.957	.000	.000	.000	
	N	540	540	540	540	540	540

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7 presents the results of calculating the multi-logit choice models for tourists traveling to Da Lat city. No impact of the cost variable on tourists' motorcycle choices to Da Lat is observed, but it does affect the choices of car, airplane, and coach for tourists traveling to Da Lat. The negative coefficient of the cost variable is reasonable because tourists tend to choose cheaper transportation modes to travel to Da Lat. The travel time variable only affects the choices of motorcycle, coach, and airplane, and no impact on the car choice is observed. The negative coefficient of the travel time variable is reasonable because tourists tend to choose faster transportation modes to travel to Da Lat.

Table 8 presents the results of calculating the multi-logit choice models for tourists traveling to Da Lat city under the assumption of having a Park and Ride (PnR) facility. Tourists have the option to choose between driving their car, taking a coach, or parking their car at the PnR terminal and then using public transportation to the city center. The calculation results show that the cost variable and the parking fees in the city center have an impact on tourists' car choice when traveling to Da Lat. On the other hand, the service quality of public transportation from the PnR facility and PnR parking fees affect tourists' decision to use the PnR. No impact of parking fees, PnR fees, and public transportation service quality on the choice of coach is observed, which is reasonable since tourists using coaches do not need to park their vehicles. The decision to choose the coach depends only on the travel time, gender, and income of the tourists. Individuals with higher incomes tend to choose cars more often, while those with lower incomes tend to choose coaches more often. No impact of the income variable on the decision to use the PnR is observed.

Table 4. Correlation test of variables (tourists in Da Lat).

		Age	Gender	Income	Dis	Time	Cost
Age	Pearson Correlation	1	-.046	**.520****	.008	-.028	.075*
	Sig. (2-tailed)		.187	.000	.824	.433	.034
	N	810	810	810	810	810	810
Gender	Pearson Correlation	-.046	1	-.107**	.006	.034	-.013
	Sig. (2-tailed)	.187		.002	.856	.337	.710
	N	810	810	810	810	810	810
Income	Pearson Correlation	**.520****	-.107**	1	-.058	-.111**	.041
	Sig. (2-tailed)	.000	.002		.102	.002	.248
	N	810	810	810	810	810	810
Dis	Pearson Correlation	.008	.006	-.058	1	**.792****	**.498****
	Sig. (2-tailed)	.824	.856	.102		.000	.000
	N	810	810	810	810	810	810
Time	Pearson Correlation	-.028	.034	-.111**	**.792****	1	.337**
	Sig. (2-tailed)	.433	.337	.002	.000		.000
	N	810	810	810	810	810	810
Cost	Pearson Correlation	.075*	-.013	.041	**.498****	.337**	1
	Sig. (2-tailed)	.034	.710	.248	.000	.000	
	N	810	810	810	810	810	810

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5. Mode choice model of Da Lat citizens.

		B	S.E.	Wald	df	Sig.	Exp(B)
MC	Distance	0.166	0.048	11.928	1	0.001	1.180
	Time	-0.041	0.008	30.247	1	0.000	0.959
	Cost	-0.059	0.026	5.062	1	0.024	0.942
	Constant	2.717	0.273	99.326	1	0.000	15.135
Car	Distance	0.216	0.03	51.099	1	0.000	1.241
	Time	-0.024	0.007	11.204	1	0.001	0.977
	Cost	-0.041	0.004	98.625	1	0.000	0.960
	Constant	1.291	0.113	61.234	1	0.000	3.635
By	Time	-0.021	0.002	147.366	1	0.000	0.979
	Constant	0.574	0.086	42.156	1	0.000	1.776
Bus	Time	-0.043	0.008	25.768	1	0.000	0.958
	Distance	0.233	0.037	39.115	1	0.000	1.263
	Constant	-2.573	0.241	87.614	1	0.000	0.076

Table 6. Mode choice model of tourists in Da Lat.

		B	S.E.	Wald	df	Sig.	Exp(B)
MC	Gender	.759	.162	22.046	1	.000	2.136
	Time	-.099	.014	48.739	1	.000	.906
Car	Gender	-.753	.228	10.855	1	.001	.471
	Income	.704	.110	41.197	1	.000	2.022
	Cost	-.022	.006	12.227	1	.000	.978
By	Time	-.032	.004	80.471	1	.000	.969
	Cost	-.166	.018	81.666	1	.000	.847
Bus	Time	-.014	.005	7.108	1	.008	.986
	Gender	.586	.185	10.022	1	.002	1.797

	Income	-.149	.078	3.638	1	.056	.862
Co	Time	-.088	.012	50.293	1	.000	.916
	Cost	-.055	.016	12.604	1	.000	.946

Table 7. Mode choice model to Da Lat of tourists "without Park and Ride".

		B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
MC	Time	-.001	.000	13.201	1	.000	.999
Car	Cost	-.002	.000	22.556	1	.000	.998
	Income	.239	.059	16.616	1	.000	1.270
Plane	Cost	-.002	.001	11.241	1	.001	.998
	Time	-.021	.007	7.964	1	.005	.979
Co	Time	-.002	.000	43.985	1	.000	.998
	Cost	-.003	.000	40.782	1	.000	.997

Table 8. Mode choice model to Da Lat of tourists "without Park and Ride"; b. Mode choice model to Da Lat of tourists "with Park and Ride".

		B	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
Car	Income	.428	.127	11.281	1	.001	1.534
	Parking fee	-.049	.010	22.445	1	.000	.952
	Cost	-.006	.002	6.110	1	.013	.994
Co	Time	-.007	.004	3.382	1	.066	.993
	Gender	1.056	.287	13.495	1	.000	2.874
	Income	-.411	.129	10.071	1	.002	.663
Car +PnR +Bus	Time	-.013	.003	17.540	1	.000	.988
	PT quality	.930	.246	14.265	1	.000	2.533
	PnR fee	-.008	.006	1.693	1	.193	.992

4.2. The Impact of Improving the Quality of Public Transport, Parking Fees, and Park and Ride on the Public transport share

The objective of Da Lat City is to develop short- to long-term solutions to gradually improve the transportation system within the city area in a synchronized, modern, and technology-driven manner, utilizing information technology in traffic management. The goal is to rapidly develop public passenger transportation, gradually mitigate traffic congestion, and reduce traffic accidents. The specific objectives are as follows: by 2035, to minimize traffic congestion, ensure safe and smooth traffic operations, and manage and exploit the system in a synchronized, modern, and flexible manner. The aim is for public transportation to meet 10-15% of the travel demand. By 2025, the share of public transportation in the total travel demand should reach 8%-10%. The mode choice model estimated previously is used to test scenarios for solutions improving the quality of public transport, parking fee policies, and Park and Ride on public transport share. A range of parking fees and congestion fees from 5,000-50,000 VND for motorcycle and 20,000-200,000 VND for car, as well as increases in travel time from 5 to 20 minutes, are tested. The results show that to meet 5%, 10%, and 15% of the demand, some of the following solution scenarios (Table 9-11) can be applied:

Table 9. Scenarios of solutions for citizen travel demand.

%PT	Measures proposed	
5%	1	Increase the fees for cars and motorcycles respectively 50,000 VND and 20,000 VND (including parking fee and congestion fee)
	2	Increase the parking fees for cars and motorcycles respectively 25,000 VND and 15,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals,
	3	Increase the parking fees for cars and motorcycles respectively 20,000 VND and 10,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals + Reducing travel time by bus (increasing frequency, improving accessibility to bus stops
10%	1	Increase the parking fees for cars and motorcycles respectively 70,000 VND and 35,000 VND (including parking fee and congestion fee)
	2	Increase the parking fees for cars and motorcycles respectively 60,000 VND and 30,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals,
	3	Increase the parking fees for cars and motorcycles respectively 60,000 VND and 30,000 VND, combined with reducing travel time by bus and bicycle
	4	Increase the parking fees for cars and motorcycles respectively 40,000 VND -60,000 VND and 20,000 VND -30,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals and Reducing travel time by bus (increasing frequency, improving accessibility to bus stops
15%	1	Increase the parking fees for cars and motorcycles respectively 150,000 VND and 46,000 VND (including parking fee and congestion fee)
	2	Increase the parking fees for cars and motorcycles respectively 150,000 VND and 40,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals,
	3	Increase the parking fees for cars and motorcycles respectively 120,000 VND and 40,000 VND, combined with reducing travel time by bus and bicycle
	4	Increase the parking fees for cars and motorcycles respectively 90,000 VND -100,000 VND and 35,000VND - 40,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals + Reducing travel time by bus (increasing frequency, improving accessibility to bus stops

Table 10. Scenarios of solutions for tourist travel demand in Da Lat.

%PT	Measures proposed	
5%	1	Increase the fees for cars 60,000 VND (including parking fee and congestion fee)
	2	Increase the fees for cars 30,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals,
	3	Increase the fees for cars 20,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals, + Reducing travel time by bus (increasing frequency, improving accessibility to bus stops)
10%	1	Increase the fees for cars 80,000 VND -200,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals and Reducing travel time by bus (increasing frequency, improving accessibility to bus stops)
15%	2	Increase the fees for cars 90,000 VND -250,000 VND, combined with increased travel time due to parking, traffic congestion, and no priority at traffic signals + Reducing travel time by bus (increasing frequency, improving accessibility to bus stops

Table 11. Effects of solution options on mode share of tourist travelling to Da Lat.

Effectiveness		Mode	Increasing of parking fee in downtown (thousand VND /2h)				
			0	5	10	15	20
PnR fee (Thousand VND/day)	0	Car	37%	32%	28%	25%	22%
		Bus	0%	2%	2%	2%	3%
		Coach	63%	66%	69%	73%	76%
	20	Car	36%	32%	29%	25%	22%
		Bus	2%	2%	2%	2%	3%
		Coach	63%	66%	69%	73%	76%
	30	Car	36%	32%	29%	25%	22%
		Bus	1%	2%	2%	2%	2%
		Coach	63%	66%	70%	73%	76%
	40	Car	36%	32%	29%	25%	22%
		Bus	1%	1%	2%	2%	2%
		Coach	63%	66%	70%	73%	76%
Enhancing public transport quality	Good	Car	35%	31%	27%	24%	21%
		Bus	3%	4%	4%	5%	5%
		Coach	62%	65%	69%	72%	74%
	Very good	Car	32%	28%	25%	21%	18%
		Bus	7%	8%	9%	10%	11%
		Coach	60%	63%	66%	69%	71%

Table 12. Public transport quality level.

No	Indicators	Current status	Good level	Very good level
1	Punctuality Reliability	**	***	*****
2	Frequency	**	***	*****
3	Accessibility	*	***	*****
4	Comfort & Cleanliness	*	***	*****
5	Safety Security	****	****	*****
6	Affordable	*****	*****	*****
7	Info. & Com.	**	***	*****
8	Environmental Impact	*	***	*****
9	Customer Satisfaction	*	***	*****
10	Integration of Transport	*	***	*****

Applying the mode choice model estimated for the travel demand of tourists visiting Da Lat, we estimate that, the development of road infrastructure, such as constructing a highway system, will increase the demand for private cars from 24.5% to 36.5% (assuming other factors remain unchanged). Therefore, to mitigate traffic congestion, in addition to road infrastructure development, other solutions need to be combined, such as the Park & Ride solution, increasing the parking fees for cars in the city center, and improving the quality of public transport services (Table 12) to encourage a shift towards the use of public transportation instead of private vehicles. The cumulative effects of these solution options, including the Park & Ride, increasing the parking fees for cars in the city center, and improving the quality of public transport services, are presented Table 11.

The results in Table 11 show that parking fees in the city center significantly reduce the number of car trips to the city center and slightly increase the usage of Park & Ride. The Park & Ride fees have a minor impact on the number of car trips to the city center and the usage of Park & Ride. Significant improvements in the quality of public transport services contribute to an increased usage of Park & Ride. Only by improving the quality of public transportation services can the usage of Park & Ride reach 5% and 10% or higher.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis results, the following conclusions and policy implications can be drawn: 1) For the travel of city residents in Da Lat and of tourists within Da Lat, implementing solutions such as increasing motorcycle and car parking fees, reducing travel time using public transportation (by increasing the frequency of trips, improving accessibility to waiting stations, prioritizing traffic signals, etc.), and increasing travel time using private vehicles (due to increased traffic congestion, lack of traffic signal priority, etc.) are feasible measures to increase public transport share to 15%; 2) Concerning the travel of tourists to Da Lat, implementing solutions such as increasing parking fees for cars have a slight impact on increasing the usage of public transportation and Park & Ride. Increasing parking fees at Park & Ride facilities also has a minor effect on reducing the usage of public transportation and Park & Ride. Only by improving the quality of public transportation services can there be a significant effect on increasing the usage of public transportation and Park & Ride. Therefore, to ensure the feasibility of the Park & Ride solution and achieve a public transport split rate of 10%, it is necessary to enhance the quality of public transportation services combined with increasing parking fees for cars in the city center; 3) Policymakers can use these findings to develop effective strategies to enhance public transport quality and promote sustainable urban transport systems. The study results could be more insightful with a larger sample size in a survey, allowing for the evaluation of not only time and cost but also other factors in the mode choice model. In that case, we can evaluate the effectiveness of other strategies on enhancing the public transport service quality, on traffic demand management, and so on.

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