Mode of Transport and Inequity in a Least Developed Country: The Case of Vientiane, Lao PDR

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Abstract: In 1986, Laos opened its doors to the global market. With new economic policy mechanisms in place, the country has developed dramatically over the years. The rapid growth brought forth opportunities as well as challenges. This study analyzes traffic congestion in Vientiane, the capital, with a focus on transport mode choices and inequity among commuters. Due to the lack of a reliable database in Laos, the initial step entailed collecting a set of origin–destination data. A total of 498 samples were randomly processed in the data survey, consisting of personal data, household conditions, and travel behaviors. To identify the flow of transport and mode choices, descriptive analysis and a multilevel logit model were employed. The findings reveal the insufficiency of public transit in Vientiane. The preferred modes of transport are motorbikes and private cars. Commuters who use private cars lie in the higher income group, while the low-income group consists of residents who use motorbikes. In addition, the low-income group takes longer to commute as compared to the high-income group. Overall, the lack of public mode choices encourages the use of private cars, leading to critical inequality between low and high-income groups.

Keywords: transport mode choice; urbanization; inequity; origin-destination data; least developed county

1. Introduction

Many large capital cities in developing countries are confronting environmental issues, social inequality, climate change, and traffic congestion, among other problems. Large metropolises such as New Delhi, India, Bangkok, and Thailand are grappling with the problem of an over-concentration of private vehicles. Lao PDR (Laos), a country on the list of least developed countries (LDCs), is also encountering a similar situation. In 2015, the United Nations (UN) reported that Laos was the fastest urbanizing nation among Southeast Asian countries [1]. In recent decades, Vientiane, the capital, has become crowded due to an increase in employment and investments [2]. Vientiane has become a hub of business and culture with more than 750,000 inhabitants [3]. According to 2015 national statistics, Vientiane is the most densely populated area among 18 administrative provinces of Lao PDR. Due to the prevailing circumstances of LDCs and rapid urbanization, as in the case of Laos, various socio-economic problems including environmental issues, health, economic stability, and road traffic have emerged.

To overcome these challenges, the government has employed both physical and socio-economic planning approaches. Urban and transport planning includes long-term strategies that can be used to mitigate congestion [4]. The key vision pertaining to the capital's urban development by 2030 is to make Vientiane an eco-friendly, livable, and sustainable city. In terms of urban development policies, urban growth management is critical which addresses the urban sprawl. However, the city's dispersed development pattern has led to poor infrastructure and high transit costs. Additionally, private automobiles are

most likely to be the most preferred mode of transport. Massive automobile dependency can lead to social inequality, high transit costs, and air pollution [4,5].

Traffic congestion has become a serious concern in most big cities, and it is tough to find a permanent solution to the problem; preferred mode of transport is an important indicator for identifying the trends in car ownership. Land-use patterns, job-housing balance, population density, and mixed-use approaches have been the primary causes associated with selection of public transport [6–8]. Cervero [9] asserted that although new town development or new zone identification (new land-use planning) would be an indirect approach to solving traffic congestion, encouraging the use of public transit would undoubtedly help to tackle the problem of automobile dependency.

Studies regarding the preferred mode of transport in Asian countries (e.g., Thailand and Vietnam) have been conducted. Analysis of the preferred mode of transport in Thailand revealed diverse characteristics of both public and private modes. The majority of people prefer commuting by cars and motorbikes. The rapid increase in private cars, taxies, and motorbikes has resulted in extreme traffic congestion during peak hours [10]. Hanoi in Vietnam, is well-known for its use of two-wheeled vehicles. Commuters take diverse routes to work; high-income workers prefer living and working in the urban core, while low-income workers prefer suburban areas. In both Hanoi and Thailand, more than 70% of people use motorbikes to commute [11]. Numerous studies have analyzed transit and urban development policies, for instance, Shao et al., 2020 [12] addressed the importance of public transportation system development in promoting densification and economic growth [12]. In addition, suitable access to public transportation may support urban development along with transit stations [13].

However, to the best of our knowledge, no study has been conducted on commuters' choice of mode of transport and behavior in Vientiane, where a car-oriented approach has emerged along with inequality. This study emphasizes the income status and preferred mode of transport of the residents of Vientiane for day-to-day commuting. Thus, this study represents an initiative to support effective transit solutions in both policy-making and urban planning in Laos while also addressing social inequality.

The central area of Vientiane was selected for the study. Data sources consist of empirical surveys and related documents. Primary data were randomly collected from households and vehicle flow in the inner city of Vientiane. Secondary data were gathered from several government reports, related publications, and technical studies. To analyze the results, descriptive analysis and a multilevel logit model were employed to identify mode choice and commuter behaviors. Further, case studies of many countries were taken into account in order to explore best practice lessons. The directions of many of these approaches could be a significant answer to the question of inequality in transport, and could be adopted in real practice in the case of Vientiane, Laos.

2. Theory and Research Question

Both developing and developed nations have experienced, and are still experiencing, the problem of urbanization and overcrowding. These phenomena have produced various negative effects such as traffic congestion, pollution, housing problems, and social segregation. To combat the problem of congestion, diverse approaches have been adopted based on government policies and planning instruments [14–16]. Many cities around the world have implemented policy initiatives that encourage the use of public transit to mitigate the problems of on/off-street parking, traffic congestion, accidents, and pollution [17].

Public transit is a crucial factor that affects economic and social development in cities. The significant components of the economy and society are well-known domains of sustainable development goals. Therefore, along with economic development policies, public transit should address social equity at all levels of income [18–20]. For instance, income inequality in developing countries can have critical implications regarding choice of residence and use of public transit [21]. Whalen et al. studied the mode choice of transport behaviors during school trips at McMaster University Hamilton, Canada; transit costs,

commuters' attitudes, and the physical environment were the key factors influencing the choice of transport mode [22].

Choice of mode of transport is a vital component of transport planning, which concerns the characteristics pertaining to commutation in a city. In the US, personal trips have been classified under the categories of work trips, recreation, shopping, and social activities, and comprise more than 80% of all trips. Many studies have examined the relationship between the workplace, commercial areas, and residential locations, as well as between household and transit data [23–25]. In South Korea, many scholars have compared household characteristics and transit data to explore commuting behavior [26–28]. In terms of transport mode choice, private automobiles account for a high percentage. Recently, the number of transport mode choices has been increasing in both urbanized and suburbanized areas of South Korean cities. Scholars have continuously investigated the issues of transit development in the Seoul metropolitan area. Findings reveal that if commuters do not have access to efficient public transit service, they prefer private or car-oriented transport [29–31]. Based on the above articles, it found that both the US and South Korean cities have experienced a high magnitude of personal trips to high-income countries status.

Income is a key factor influencing commuters' transport mode choices. In low-income, developing countries, the use of motorbikes has risen consistently. In Vietnam, motorbikes have become a popular mode of transport associated with a reasonable cost for daily use. However, public transport choices were rated poorly in terms of management and support services [11,32]. On the contrary, Singapore is a high-income Asian state that employs various approaches to tackle traffic congestion through national transport planning strategies. To control the flow of private vehicles, the Singapore government focuses both on social and economic factors, such as increasing taxes on private vehicles, planning for land-use, public transport development and management, and encouraging citizens to use public transit [33].

In Asian countries, the flow of private vehicles has obviously increased in megacities. In Bangkok and Thailand, traffic congestion has become a grave problem, and statistics indicate a twofold increase in motorized mode registration. To decrease dependency on motorized modes, the government has launched many initiatives to operate an efficient public transport system. However, it will take another decade to solve this problem due to the popularization of private automobiles [10,34,35]. In the least developed countries, transport mode selection is associated with income levels. With regard to a study in the metropolitan city of Nepal, inequality in transport mode preference was influenced by different income groups [36].

The choice of mode of transport in many developing nations primarily consists of two-wheeled motorbikes and automobiles [37,38]. The use of motorbikes, especially in low-income countries has rapidly increased, which has led to a proportional rise in the number of accidents. Minimizing the growing use of motorbikes could be an alternative option to reducing traffic congestion in Malaysia. Ibrahim Sheikh et al. [39] conducted a case study in Malaysia and concluded that mode of transport, time spent in travel, and cost should be affordable for low-income groups. Time spent on travelling shows a key factor in transport cost and value of time. The value of time in transport is directly associated with transport mode choices both in developed and least developed countries, also revealed are the convenient circumstances which play a critical role in the marginal utility of the time value and travel cost [40]. In some studies, the value of time would not only be directly interpreted as monetary value but also in terms of the consumer's behavior, health care, and insurance aspects [41]. In addition, in order to balance the transport costs and benefits, efficient tariff is necessary to be considered together with the time value [42]. Low-cost and efficient services of public transit are likely to encourage commuters to shift from motorbikes to public transport and establish equality in society [39].

Shivonne et al. [43] pointed out that the inequality in using public transport is a crucial indicator of poverty in LDCs. The inequality in transit planning can be identified via factors such as income, car ownership, public transit accessibility, and safety conditions [44]. As

such, patterns of transport mode choices and transit development approaches in both developing and developed states were investigated for the present study, especially since very limited research has been carried out to explain the relationship between transport mode choice and inequality. This study attempts to offer important insights regarding the transport mode selections and inequality aspects in the case of Vientiane city, Laos.

3. Existing Data and Methodology

In developing countries, the massive use of private automobiles and motorcycles are key issues that are considered in the formulation of urban development policies. Automobile dependency is a dominant factor leading to traffic congestion. Although the use of private automobiles and motorcycles is generally beneficial for commuters, these modes also cause serious transit problems in cities. To solve this issue, the behaviors of commuters in the central part of Vientiane were analyzed with the existing cross-sectional data. Commuting behaviors, mode selections, and workplace destinations were used to capture the travel routes and flow of transportation in the central zone of the capital city. This study reviewed many cases regarding travel demand, nationwide traffic report, the urbanized condition in Vientiane city, and worldwide transit planning along with economic growth in order to find the reality in the existing context.

3.1. Urbanized Context in Vientiane

Urbanization comprises urban growth and concentration [45]. Many cities in European and Asian countries are likely to have a lower magnitude of car use per capita than cities in the US. As for cities in the US, the data illustrates a high gross regional product (GRP), which is associated with a high magnitude of car use per capita. However, in European and wealthy Asian states, a high GRP but low magnitude of car use per capita has been recorded. This evidence can serve as a clue to explain that GRP/gross domestic product (GDP) has been a co-factor associated with car use. Laos has low-income residents and a high percentage of motorized modes of transport.

Laos is a landlocked country whose population has increased along with a unique flow of economic and political power. It is divided into 17 provinces and the capital. The population growth is not the same in the case of the state's 18 territories and depends upon the geographic conditions and the locale. Statistics pertaining to the population density of each province in 2015 indicated that Vientiane had the highest population density, accounting for more than 200 people per square kilometer. The growing population in Laos is mainly concentrated in the capital city rather than other provinces by more than four to eight times [3].

Vientiane has nine administrative districts. The two smallest districts, located in the central area, are Chanthabouly and Sisattanak, which have the highest population density among the nine districts as shown in Table 1 (2562 and 2347 people per sq. km, respectively). The two cities have commercial buildings, government offices, various companies, traditional markets, shopping centers, and residential buildings. The changes in population density from 1995 to 2015 are depicted in Table 1, and reflect minimal changes that were brought about in the two cities, Chanthabouly and Sisattanak, during this particular period of time.

The population statistics reveal that the inner part of the capital is densely populated. Within a 5-km radius, the number of residents in 2005 were 3790 residents per sq. km, and a 5–10 km radius accounted for 837 people per sq. km. These values are important indicators of residential density in the heart of Vientiane.

3.2. Transport Mode Choice and Flow of Transit in Vientiane

Studies on commuting patterns using various data sources have been published in many international publications. In the US, Europe, and some Asian regions, transport data sets are produced by the relevant sectors, for instance, Korea Transport Institute (KOTI) maintains the transport and household data set. Unfortunately, it is difficult to find rich

sources of data related to commuting behaviors and patterns in Laos. However, this study tries to provide a set of existing travel data regarding origin–destination (OD) data and commuting patterns in the case of Vientiane capital.

Table 1. Population density of Vientiane.

No.	District	Area (sq. km)	Population Density (Person/sq. km)			1995–2015 (%)
			1995	**2010**	**2015**	
1	Chanthabouly	27	2028	2550	2562	16.04
2	Sikhottabong	148	508	675	818	60.85
3	Sisattanak	28	2082	2453	2347	12.71
4	Xaysetha	142	520	687	823	58.41
5	Naxaithong	982	45	59	77	69.20
6	Xaithany	845	118	178	233	97.61
7	Hadxayfong	238	275	329	410	49.14
8	Sangthong	780	22	31	38	70.96
9	Parkngum	730	47	62	67	42.62
	Average	436	627	780	819	53.06

3.2.1. Data Collection on Commuting Patterns in Vientiane

The main purpose of this study was to identify mode choices and commuting patterns in a basic sustainable form in Vientiane, the capital of Laos. The following research questions were pursued

(i).　What are the main characteristics of the modes of transport in Vientiane?
(ii).　Is there any inequity in mode selection?

In order to answer these questions, the study focused on the city center, covering a 10-km radius based on the concentration of the city population (Figure 1).

This study represents an initial approach to OD data collection in Vientiane. Analysis of data utilized in the analysis of transit issues involved both descriptive analysis and a multilevel model. In addition, this study identified the implications of the transport planning policy in Laos on commuting behavior and mode selection among commuters. A transport and travel survey was conducted in the inner area of Vientiane which is considered a high density place. Both primary and secondary data were collected. Based on recent studies focusing on commuting patterns, variables like personal, household, and travel behavior were used [25,29,30,46]. The primary data were amassed from: the traffic volume of major junctions in the inner city, covering both inbound and outbound areas (on weekdays and weekends); the OD data were collected within 10 km from the city center area of Vientiane capital. A total of 550 questionaries were randomly distributed, covering the seven main districts of Vientiane. Individual, household, and transport data (age, gender, income, occupation, car ownership, driver's license, household size, number of children, travel costs per week, and trip destination) were addressed in the questionnaire. A total of 498 (90.55%) respondents from six main districts were returned and processed in the analysis stage, and in-depth interviews with relevant entities in the transport sector were conducted. The secondary data comprised information on sustainable transport planning, problem-solving geared toward traffic congestion, related research on mode choice and commuting behaviors, and multi-level model and transport planning.
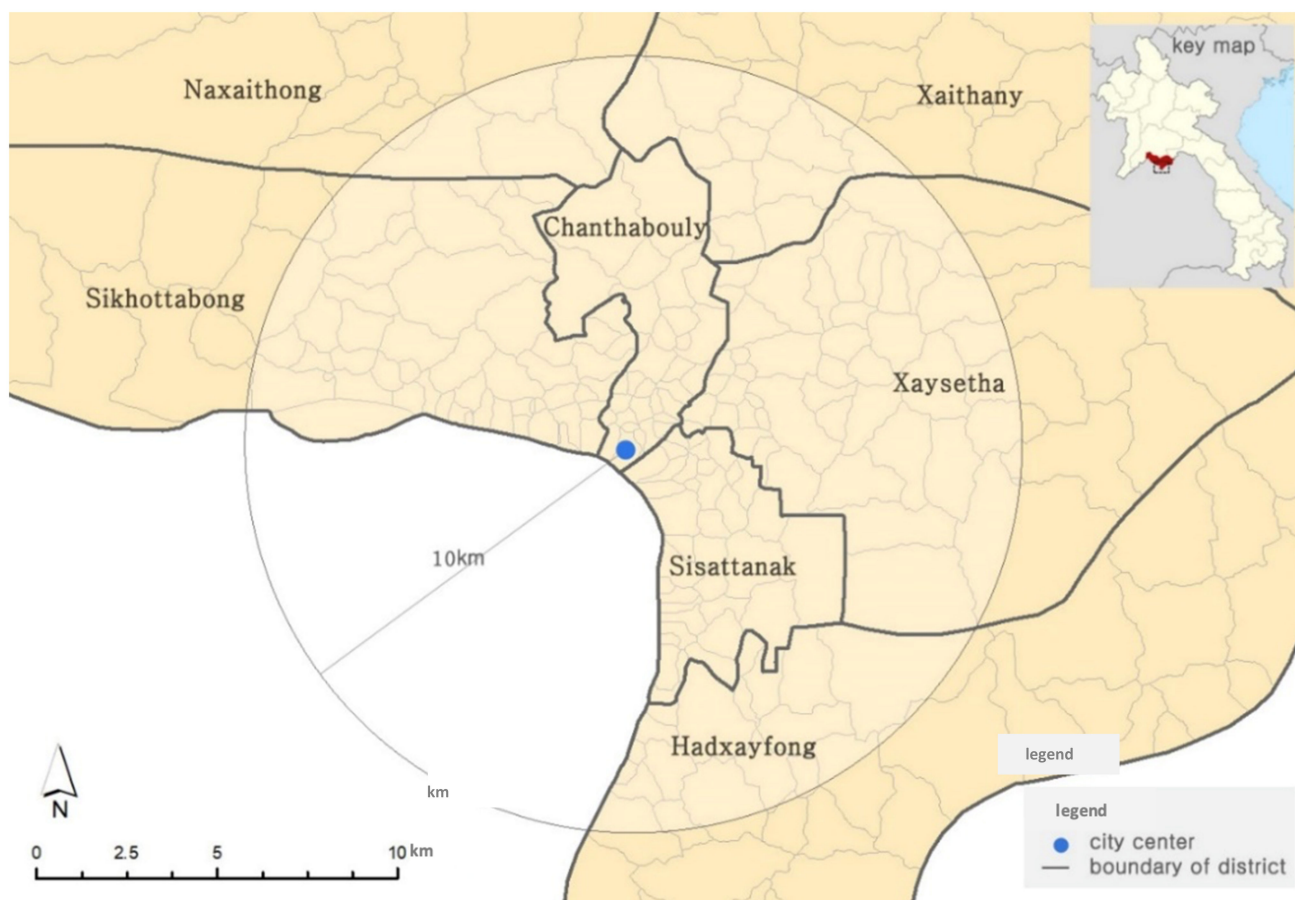
Figure 1. Map of the core area of Vientiane within a 10-km radius.

3.2.2. Trip Generation Survey in Vientiane

High-income countries are likely to be associated with car dependency since the percentage of public transit usage is associated with public development policies. Regarding the use of private cars, motorbikes, and public bus modes during 2000 to 2015, the data suggest that the residents of Vientiane followed the trend of using motorized vehicles, with the highest number of motorbikes used being more than 50,000 in 2015 [47]. This characteristic has been found in most of the developing Asian countries. On the contrary, being in the low-income category encourages citizens to select cheaper and more convenient modes of transport.

The second-highest proportion is occupied by private cars, which have increased twofold within a decade, leading to car dependency. In contrast, public bus/public transport denotes an unpopular trend in this dataset. According to the 2016 data obtained from the Ministry of Public Works and Transport (MPWT), Vientiane has a massive number of private vehicles rather than public transport modes. The dependency on private vehicles has become a critical urban development issue in transport planning in the intra- and inter-city areas.

To understand the flow of transit in Vientiane, manual counters were employed to assess vehicle density. Based on the traffic survey, both inbound and outbound traffic in the center of Vientiane indicated that the magnitude of traffic flow during weekend and weekday trips differed from weekdays (Figure 2). The most popular modes of transport for commuters in the central zone during weekdays were motorbikes and cars. The peak hour for weekend (recreational) trips was around noon. However, inbound trips showed a higher magnitude of motorbikes in contrast to outbound trips, which displayed a greater use of private cars. This could be attributed to the reason that people might be owners of additional agricultural land outside the city center where they traveled. Furthermore,

people often went for recreational trips outside the city center, which consists of botanical gardens, waterfalls, and several other tourist spots.
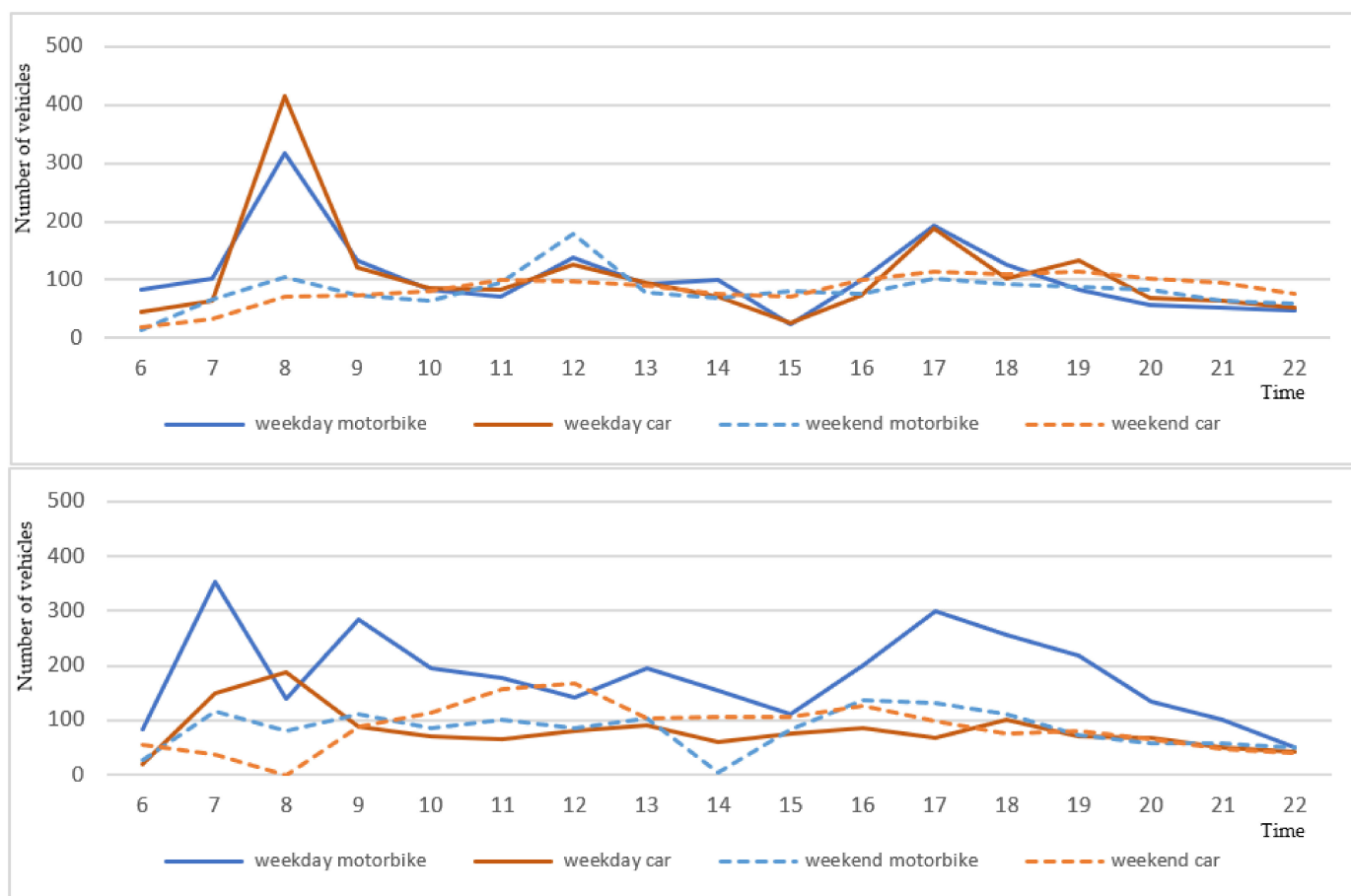
Figure 2. The flow of vehicles (**Upper**: 3 inbound junctions, **Bottom**: 4 outbound junctions). (2016 survey of weekend and weekday trips).

3.2.3. The Development Policy of Road Construction in Vientiane

This study proposes a significant development policy in Laos, which is focused on road infrastructure to support the motorized modes discussed above. Road construction projects have followed the linkage policy for the poverty reduction roadmap, which is intended to narrow the gap between urban and rural zones. Documentation of the MPWT in Laos reported the highest share of road construction projects in rural areas versus urban inner ones. The proposed policy follows the path of the national development policy, which focused on poverty reduction in the 8th Five-Year National Socioeconomic Development Plan from 2016 to 2020 [48]. The data reveal only 5% of the total number of road construction projects are allocated for inner urban areas. In reality, the expansion of several connecting roads has been proposed in the central part of the capital. However, it is a big challenge to undertake local road expansion activities due to the permanent establishment of buildings along the roads.

The transport system in Vientiane has developed slowly along with the number of private vehicles, which increased by more than double within a decade. A 2008 pilot study on the urban transport network in Vientiane found that the proportion of vehicle trips was expected to grow by approximately 2.3 times from 2007 to 2025. Hence, it is imperative that the government pay attention to the control of the flow of private vehicles in the capital [49]. The next step should be to analyze the demographic and travel behavior data in addition to the flow of vehicles on roads.

4. Findings and Discussion

Commuting patterns are a critical factor as far as urban and transport planning is concerned. Notably, in many cities in the US, Europe, and (developed) Asia, commuting patterns have been used to explain commuter behavior and transport modes. The case of Vientiane is an attempt to utilize transportation data for identifying mode choice and commuters' socio-economic conditions in the capital. The descriptive analysis and the multi-level model of the commuting patterns and mode choice behavior is discussed in the next section.

4.1. The Characteristics of Commuting Mode Choice

In order to understand mode choice, it is important to apply the travel demand model, which consists of trip generation, modal split, and trip destination. The modal split or mode choice is an approach that can be adopted to learn about the behaviors of riders, drivers, and commuters. Data from the Nationwide Personal Transportation Survey (NPTS) and Housing Survey (HS) can be used to explain commuting behaviors, demographic traits, and geographic factors that influence mode choice [50]. In Laos, collecting OD data is a complicated process; however, this study involves an analysis of Vientiane based on OD data.

This study entails both numeric and dummy variables, wherein the dummy variables were coded accurately on the basis of the characteristics of each variable. Choice of the mode of transport served as the dependent variable that included personal cars and motorbikes. The dependent variable was set as 0 (if the respondents used personal cars) and 1 (if they used personal bikes). Out of the total sample (N = 498), 266 (53.41%) shared that they used personal cars and 232 (46.59%) said they use motorbikes for their trips.

$$\text{logit}(p_{ij}) = \beta_{0j} + \beta_1 x_{1j} + \zeta_j^{(2)} + \epsilon_{ij} \tag{1}$$

$$(y_{ij} \mid p_{ij}) \sim multilevel$$

where p_{ij} is a binary dependent variable of nested data i in j; $\zeta_j \sim N\left(0, \sigma_\zeta^2\right)$ and $\epsilon_{ij} \sim N\left(0, \sigma_\epsilon^2\right)$. ζ_j is a random intercept and ϵ_{ij} is a residual error. Household and village are set as level 1 and the level 2 is district level.

A simple Chi-square test and t-test were employed to identify the gaps between the independent variables associated with the mode of transport (car and motorbike). A total of 11 independent variables were considered; however, based on the possibility of the indicators, only 10 independent variables were selected for analyzing the data. The variable of housing type was omitted due to gaps in the sample group. Since 90% of Laos' citizens reside in detached, single-family homes, only one type of housing is represented in this analysis. The 11 variables that were selected included age, gender, income, occupation, car ownership, driver license, household size, number of children, travel costs per week, travel time, and trips (Table 2) within 10 km.

4.2. Mode Choice and Inequity

Table 3 outlines the mode choices in Vientiane, the results revealed that only a few modes of transport were used daily. People rarely used different modes for daily commutes. Based on the statistics from the MPWT, the transport modes consist of motorbike, car, bus, tuk-tuk, taxi, and bicycle. Only a few residents use public transport (buses). The tuk-tuk and taxi are more popular among tourists. The analysis revealed that the commuters preferred using private cars and motorbikes. Thus, the results revealed the use of two significant modes of transport. The two aforementioned transport modes were utilized as the key dependent variables.

Table 2. Descriptive analysis of mode choices.

Variable		Car	Motorbike	Statistical Test
Age	20~29 (1)	48 (18.05)	91 (39.22)	$X^2 = 29.77$
	30~39 (2)	87 (32.71)	61 (26.29)	$p = 0.000$ ***
	40~49 (3)	70 (26.32)	35 (15.09)	
	50 plus (4)	61 (22.93)	45 (19.40)	
Gender	Female (0)	116 (43.61)	109 (46.98)	$X^2 = 0.57$
	Male (1)	150 (56.39)	123 (53.02)	$p = 0.450$
Income (1000 kip)	500~1000 (1)	6 (2.26)	21 (9.05)	
	1100~1500 (2)	60 (22.56)	99 (42.67)	$X^2 = 43.11$
	1600~2000 (3)	132 (49.62)	84 (36.21)	$p = 0.000$ ***
	More than 2000 (4)	68 (25.56)	28(12.07)	
Occupation	Student/Part-time job (1)	15 (5.64)	49 (21.12)	
	Government officer (2)	102 (38.35)	52 (22.41)	$X^2 = 49.14$
	Small business owner (3)	35 (13.6)	20 (8.62)	$p = 0.000$ ***
	Farmer (4)	1 (0.38)	1 (0.43)	
	Company officer (5)	94 (35.34)	68 (29.31)	
	Other (6)	19 (7.14)	42 (18.10)	
Household size (person)	Mean	5.27	4.95	t = 1.82
	SD	2.01	1.86	$p = 0.068$ **
Number of children (person)	Mean	0.65	0.56	t = 1.24
	SD	0.87	0.81	$p = 0.22$
Car ownership	No (0)	4 (1.50)	25 (10.27)	$X^2 = 25.42$
	Yes (1)	262 (98.50)	207 (89.22)	$p = 0.000$ ***
Driver license	No (0)	11 (4.14)	42 (18.10)	$X^2 = 25.42$
	Yes (1)	255 (95.86)	190 (81.90)	$p = 0.000$ ***
Travel costs per week (kip)	Mean	198,364.70	29,991.38	t = 30.11
	SD	84,331.19	12,723.16	$p = 0.000$ ***
Travel time (min)	Mean	26.59	23.67	t = 2.28
	SD	14.79	13.35	$p = 0.022$ **
Trip destination within 10 km	Live inside-work inside (0)	251 (94.36)	218 (93.97)	$X^2 = 0.035$
	Live inside-work outside (1)	15 (5.64)	14 (6.03)	$p = 0.851$

Note: *** $p < 0.01$, ** $p < 0.05$, values inside the brackets indicate the percentage of each group.

The findings of this study imply that older age groups are more likely to use private cars rather than motorbikes for longer trips (the first variable of Table 3). As for gender, males are more likely to commute by car than females. Wachs [51], who focused on gender and commuting patterns, found similar outcomes. He asserted that females made shorter trips than males and used public transport rather than private cars. Regarding the household income variable, income indicates that high-income groups tend to use cars. These phenomena signal that people having stable incomes tend to choose the best option for their commute. Regarding transport costs and time as evident in Table 3, commuters who use private cars are associated with high transport costs and a short commute, whereas commuters who use motorbikes are likely to need more time to commute. Lucas [44] referred to a case in the UK where inequality in transport planning could serve as a disadvantage with respect to choice of transport mode and could lead to social exclusion. Without diverse transport modes, car-oriented behavior could lead to inequality in mode selection. Lower-income groups would be forced to use the cheapest mode of transport along with the risk of safety, crimes, and accidents. The results are also critical in terms of land use planning and urban structure networks. Transport planning issues should be considered alongside with public realm networks to achieve efficient, livable, walkable cities [52,53]. Considering the economic growth patterns, low-income groups could be

pushed out to suburbanized areas characterized by low land price conditions with poor connectivity and public realm networks.

Table 3. Model of mode choice (Car = 0, Motorbike = 1).

Variable		Coef.	Std. Err.	Z	Sig
Age (20–29)	30–39	−4.12	3.77	−1.09	0.276
	40–50	−1.67	2.46	−0.68	0.498
	>50	−6.61	3.36	−1.97	0.049 **
Gender (female = 0)		4.31	1.70	2.53	0.011 **
Income (500,000~1,000,000)	1,1000,000~2,000,000	−3.64	3.54	−1.03	0.304
	2,100,000~3,000,000	−4.18	3.42	−1.22	0.221
	More than 3,000,000	−10.33	4.87	−2.12	0.034 **
Student/Part-time job	Government officer	−0.46	2.83	−0.17	0.869
	Small business owner	3.38	5.76	0.59	0.556
	Farmer	4.78	1591.15	0	0.998
	Company officer	2.45	3.43	0.72	0.473
	Other	−3.31	2.57	−1.29	0.196
Car ownership (no = 0)		−6.16	3.01	−2.05	0.04 **
Driver license (no = 0)		−6.12	3.97	−1.54	0.123
Household size		−0.18	0.52	−0.34	0.73
Number of children		−0.13	1.06	−0.12	0.901
Travel costs per week		−0.01	0.01	−2.55	0.011 **
Travel time (home to workplace)		0.26	0.13	2.11	0.034 **
Trip destination within 10 km of the city center		5.19	3.77	1.38	0.168
Cons		19.40	8.87	2.19	0.029
Var (1)		2.899×10^{-15} (7.614×10^{-8})			
Number of level 1 units		498			
Number of level 2 units		6			
Log likelihood		−14.07			

Note: ** $p < 0.05$.

5. Conclusions

Laos is an LDC characterized by dynamic economic growth. In 1986, Laos launched a new mechanism of economic development policy to support growth. In addition, many policies have been formulated for the development of rural as well as urban areas. To shift from a least developed to developed status, the Laotian government has focused on issues such as road construction, village, and infrastructure development [3,48,49,54]. However, problems associated with urban and transport planning need to be mitigated through the formulation and execution of proper strategies. Comprehensive urban and transport planning is crucial for long-term urban growth. Many countries, including developing and developed nations, have implemented numerous urban and transportation planning strategies to solve social issues, environmental crises, and traffic congestion. In recent decades, traffic congestion has been a problem of concern for urban expansion and the social and economic status of a country. Issues related to traffic congestion can be identified by understanding transport demand models. For instance, some developed nations face the challenge of traffic congestion due to massive private car ownership, while in the

developing states, two-wheeler motorized modes are the most prevalent [55]. This study explored diverse dimensions of mode choice and inequality in the capital of Laos.

The modal split or mode choice of the transport demand model is a key instrument in urban and transport planning. Many studies have underlined the problems of traffic congestion based on empirical studies of mode choice by utilizing OD data. Similarly, the present empirical study of mode choice in Vientiane plays a vital role in identifying issues related to traffic congestion. Due to the lack of OD data in Laos, it was gathered here. The data were analyzed using both descriptive and multi-level models.

First, insufficient public transit modes were found to be associated with private car and motorbike dependency. Second, the status of an LDC characterized by dynamic economic growth was associated with the trend in private car dependency. In addition, the extent to which motorbikes were used suggested that they are the most popular transport mode in Vientiane, accounting for more than double the use of private cars. Third, low-income commuters are more likely to use motorbikes, which would be interpreted as an income gap. As such, cheap, affordable, and convenient modes meet the lifestyle requirements of low-income groups [18–20].

The results of this study reveal that the use of cars and motorbikes is likely to increase shortly. To mitigate car and motorbike dependency in the city center, the government has planned to relocate some government offices to the urban fringe, about 17 km away from the center. However, according to previous studies, shifting the concentrated workplaces of employees without striking a balance between residences and jobs is likely to impact the long-term goal of sustainable growth [56]. The case study of Vientiane city could bring diverse lessons for transport and urban planning sectors, especially for policymakers. The low-income group takes longer to commute as compared to the high-income group, as poor urban networks and infrastructures may exist for the low-income group. The huge burden on transport costs would be left to the low-income group in the urban sprawl context. On the other hand, the automobile dependency phenomenon would be concentrated in the city center area. In order to mitigate these problems, public transport development policy should be implemented together with urban network and infrastructure developments [52]. Investments in public transit are vital for reducing inequality and social exclusion, and for mitigating cross-commuting issues for long-term development [29,30,57,58].

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