Challenges of Sustainable Mobility: Context of Car Dependency, Suburban Areas in Thailand

Pawinee Iamtrakul[A*]**, Sararad Chayphong**[A]

Abstract

Urbanization and transportation have caused two critical issues in the challenge of sustainable development, particularly, challenges to sustainable mobility in the context of car dependency. This is due to all aspects of environmental, social, and economic has been continued influenced by transportation related issues. The challenges of sustainable mobility in the context of suburban areas have become aggravating situation due to massive migrations, thus Pathumthani province, represented as vicinity area of Bangkok, Thailand was selected as a case study. Data were collected from 1,998 respondents by questionnaire survey and analyzed using statistical analysis and visualization based on geographic information system, GIS application. The study results revealed that the urbanization process has led to an increase in urban development that attracts enormous migrations in searching for their opportunities (working and education trips). This phenomenon has positioned Pathumthani to serve as a supportive area for the spillover of rapid urbanization in the country's capital area which has led to the development of private car-dependent travel and public transport network, mainly concentrated in urban areas with exclusion to residents in remote areas. On the other hand, most areas sprawl with a scattered density of residential settlements, which existing transportation system development can no longer serve the continued rising travel demand as before. The findings confirmed that the current development pattern could not promptly meet the needs of suburban development, requiring the policymakers to launch an effective plan to meet appropriate transportation demands and promote good quality of travelling for the residents and commuters.

Keywords: auto dependency; peri-urban areas; public transportation; sustainable development; transportation impact: urbanization

Introduction

The phenomenon of urban transformation from rural to urban (urbanization) occurs worldwide, whereby populations relocate from rural to urban areas, enabling cities and towns to grow. In 2022, the rate of urbanization worldwide was at 57 percent, and turning to 70 percent of the global population living in cities in 2050. However, some statistics illustrate how urban living differs from suburban and rural living (Statista Research Department, 2022). Accordingly, urbanization is widespread in developing and developed worlds as more people tend to relocate closer in proximity to towns and cities. Thailand is presented as one of the countries where that phenomenon occurs, especially Bangkok (Iamtrakul et al., 2023a). From the analysis of urban area expansion, it was noticeably found that the development of urban areas was vastly concentrated in Bangkok. From 2000 to 2020, the trend of changes in urban areas has continued to expand due to changes in urbanization (Iamtrakul et al., 2021). The land use from green spaces to urban areas

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has been extended to contiguous territories, i.e., metropolitan areas, as a result, Bangkok and its vicinities have become sprawling cities. Its speedy development results from several problems arising from urbanization, such as uncontrolled population growth and growth along the urban infrastructures (Ammapa et al., 2022; Iamtrakul et al., 2022). The crucial issues that arise are often related to mobility in the urbanized area, especially as it concerns the availability of transportation system. Furthermore, with the problematics mentioned above, both issues of the population growth and the difficulties of urban management have been increasing at a critical stage (Iamtrakul & Chayphong, 2023). Most of the commuting options preferred by dwellers are private cars as represented as their primary choice. This presents the commuting demand by residents in a critical condition, leading to unsolved traffic congestion. This phenomenon has not arisen only in the Bangkok, however the scope of the problem has extended to the surrounding provinces, consisting of Bangkok, Nakhon Pathom, Nonthaburi, Pathum Thani, Samut Prakan, and Samut Sakhon. Suburbanization occurred in these areas affected by the rapid and fragmented urban development in sprawling pattern, resulting in attracting factors (pull factor) for immigrants to enter the city in terms of access to jobs, education, utilities, public utilities, and public services.

Consequently, Pathum Thani Province which is represented as a peri-urban area supporting population expansion from Bangkok which induced massive potential in terms of allocation of facilities and services and a large concentration of activities, e.g., agricultural, commercial/industrial areas, and higher education institutions (Iamtrakul & Chayphong, 2021). However, over 70 percent of the province's gross domestic product is generated from the industrial sector which is also significant driven based on commercial divisions as well, thus causing the instant growth of the adjoining areas. However, when urban planning and management are considered, it was found that there needs to be more efficient traffic network systems and effective transport management, resulting in numerous problems, especially traffic complications. This is evidence that Pathum Thani's traffic volume ratio to road capacity (Vehicle Ratio (VCR)) during the morning and evening rush hour is more significant than 1.00. Furthermore, road safety statistics showed that Pathum Thani has a road accident fatality rate of 9.6 per 100,000 people and is ranked number 1 in the metropolitan area. (Thai Roads, 2017). Without a doubt, there is also the problem of air pollution with an average PM. 2.5 as of 2019 with more than 160 micrograms per cubic meter, which is considered at a health risk. Therefore, supporting a seamless travel connection model within the nodes of activity and surrounding areas is necessary to fill the planning gaps and, in turn, reduce the need to travel with a personal car. Therefore, it is necessary to tackle these problems and prepare for better future transportation development opportunities in Pathum Thani province.

Literature review

Increasing global urbanization brings challenges and opportunities for sustainable development, particularly in developing countries (Haider & Iamtrakul, 2022). Urban transport is one of the significant elements in the primary production process to drive economic development, especially in urban areas of megacities. Connectivity among routes and vehicles for travelling are necessary for more convenience and efficiency. The availability of such linkage should be designed to sufficient support passenger travel and freight and goods for transportation, including the development of urban economic agglomeration areas. Therefore, the development of transportation systems should be considered as the priority of urban development planning, which is the key factor that makes the transportation system particularly important to the development of urban areas. Urbanization brings several challenging impacts within urban/city, such as medical services and health dimension (Liu et al., 2017; Godfrey & Julien, 2005; Iamtrakul & Chayphong, 2023), urban heat island (Wang et al., 2021; Wu et al., 2020), transportation impact (Iamtrakul & Hokao, 2012; Iamtrakul et al., 2023b), environmental impact (Ponce De Leon Barido and Marshall, 2014; Ergas et al., 2016;), social inequality problems (Nguyen Minh et al., 2019; Kanbur & Zhuang, 2013), etc. That is to say, urbanization has been one of the dominant factors influencing economic, environmental, and social changes related to sustainable urban development.

For transportation impacts issues, the rapid urbanization process has produced a series of transportation impacts, such as energy consumption, environmental problem, a lack of transportation facilities, mobility problems, road safety, traffic congestion, land take, etc. (Chen et al., 2016; Iamtrakul & Hokao, 2012; Poumanyvong et al., 2012; Rodrigue et al., 2006). Urban mobility problems have increased proportionally and, in some cases, exponentially with urbanization (Rodrigue, 2020). This phenomenon needs holistic view-based solutions and searches for more sustainable

solutions. Consequently, transportation issues have become a significant problem for cities' and regions' spatial configuration associated to economic development. Since transportation stipulates the movements of people, goods, and information which are the fundamental components of urbanization and transportation development and also influences the attractiveness and desirability of urbanized areas (Banister, 1995). This may result to increase traffic volumes and frequent commuters, causing higher travel demand with appropriate and efficient planning and management. Significantly, it has been understood that the movement trend increases and shifts towards motorized transport modes or car dependency. It can also be noticed that car dependency plays a key role as one of the most influential contributing factors to air pollution, traffic congestion, risk of health problems, and energy consumption (Li & Zhao, 2017; Frederick et al., 2018). This is seriously hindering the development of sustainability.

Several studies point in the direction of applying sustainable mobility concepts to alleviate the problems of car dependency. For instance, there are some recommendations on sustainable mobility, prioritizing public transport and active mobility, channelling local funding towards promoting environmentally friendly transport modes, promoting the usage of non-motorized transport by improving walking and cycling conditions, putting in place significant investments and time-bound targets to support implementation, etc. (OECD, 2021). Notably, sustainable mobility is currently becoming a priority at the urban level, aimed at reducing the environmental impact resulting from the mobility of people and goods. Thus, sustainable mobility intends to ensure that transport systems correspond to society's economic, social, and environmental needs while helping to minimize the negative repercussions on the economy, society, and the environment (European Parliament, 2006).

Materials and methods

Study area
This paper intends to study the challenges of sustainable mobility in the context of car dependency in suburban areas in Thailand. Pathum Thani province was selected as a case study of suburbanization development. This is due to the characteristics of the site, which can be considered as a peri-urban province to support the rapid urban development of Bangkok metropolitan. As a result, within the study area, it was found a variety of activities attract migrants to commute into the area; such activities include the prospects for jobs, housing, and education (Iamtrakul et al., 2022). In addition, urban development results in essential activities that appeal many trip makers to commute to the study area. Pathum Thani Province, however, provides transportation systems and services to support the use of diverse populations, both residents and employees (e.g., walk, bicycle, bus, sky train, commuter rail, and various para transit systems). Although there are many transportation options and modes of transportation systems, the coverage of these services is yet to meet the demands of commuters in areas far from urban areas, particularly the accessibility to connect (feeder) and link to services providing affordable public transport. As a result, travelling by private car is the most popular mode of transportation in the study area.

Data Collection
The input data for the analysis process in this study consists of two parts which can be categorized into primary and secondary data, as demonstrated in Figure 1 and Figure 2. The primary data was gathered by questionnaire survey which the details of data collection is divided into two parts which are;
1. *Socioeconomic profile of respondents*: There are 5 data sets comprises of gender, age, education level, occupation, income level (average income per month per person);
2. *Travel behavior of respondents*: There are 3 data sets which are travel time (minutes), vehicle possession, and trip purposes.

The secondary data was a collection of databases which is divided into 2 parts which are;
1. *Socioeconomic profile of the study area*: was collected from secondary data by Official statistics registration systems (Official statistics registration systems, 2022). There are 8 data attributes comprising of population (Persons), number of households (households), number of houses (house), density of population (persons per area), in-migration on house registration (persons), out-migration on house registration (persons), number of employed people in formal (persons) and number of employed people in informal (persons).
2. *Physical characteristics and its developments*: were gathered from secondary data based on geographic information systems (GIS). There are 2 sets of data which consists of building characteristics (type of building: commercial, institutions, mixed use, recreations, industrial, residential) and transportation (local road, main road, public transportation, etc.).
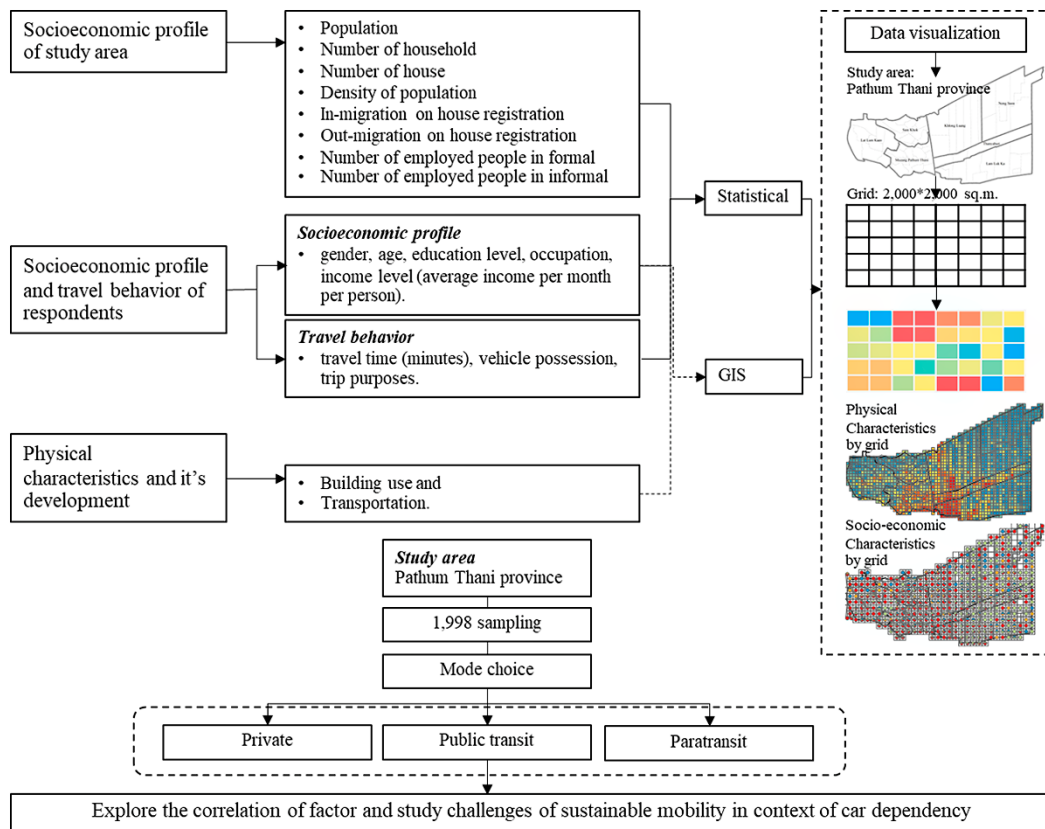
Figure 1. The framework of the study

This research was primarily conducted by using a questionnaire with 2,000 samplings. The sampling size was determined, and the sets of sample sizes were at the confidence level of 95%. The total sample size in this study was distributed to cover entire districts of the study area. Therefore, with the screening data, the final number is 1,998 sets based on the method for collecting the data on the basis of face-to-face randomization.

The survey was also dispersed by using an area of distribution at 2,000*2,000 square meter grid by considering the building density representing the population density within the grid. This was conducted to confirm the distribution of the sample data within the study area. After collecting data, the screening was performed with a focusing on eliminating missing data. Furthermore, this questionnaire was approved by the Human Re-
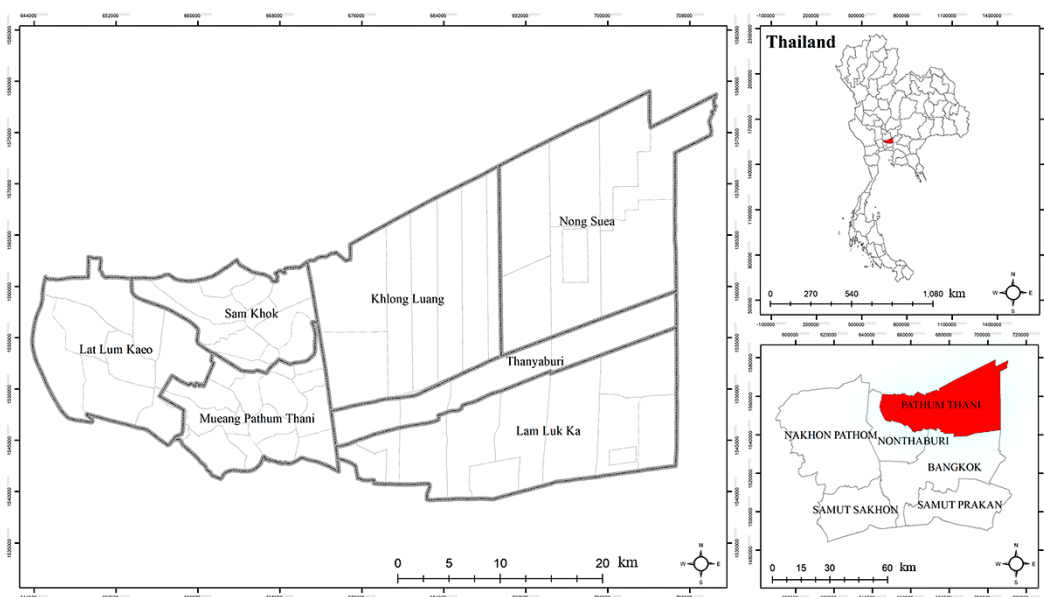

Figure 2. Study area

search Ethics Committee of Thammasat University Social Sciences (certificate of approval number 107/2022) with approval on August 15, 2022.

Method of Analysis

This study applies statistical analysis and geographic information systems (GIS), furthermore Chi-Square was adopted to explore the correlation between socioeconomic, travel behavior, and mode choice, which provides an understanding of the factors associated with car dependency in the study area. By comparing different mode choices in the analysis, the consideration was targeted to the main three types which include private categories, public transit, and paratransit. The analysis of the results is explained in the next section, as illustrated in Figure 3.

Results

Socioeconomic Profile of Study Area

Pathum Thani Province is considered a local expansion from the nation's capital with a suburban context where activity density is concentrated in the main corridor of highway network passing through the study area. In addition to the activity density of the study area, a wide variety of activity nodes was also discovered, attracting numerous commuters to the provincial area. Figure 3 demonstrates the statistical information on the social and economic characteristics of the study area at the provincial level. It also can be confirmed that the population growth rate is on the increase trend. However, the tendency of an increase is lower than in the capital city, going by the annual comparison result over the past ten years. Considering the number of migrations in and out of the housing registration, it was found that the move-in rate declined during 2013-2017. However, the trend increased during 2018-2019, after that, the number of moving in rate has declined until now which presents a consistent trend with the number of relocations. However, considering the annual data, the number of moving-in rates is greater than that of moving-out, indicating increased travelling and settlement in the area. Furthermore, this aligns with the increasing number of employees in the formal and informal sectors, especially in 2020-2021. Therefore, the increasing number of populations reflects the number of residents, as concentration of users of urban infrastructure increase accordingly.

Physical Characteristics with car despondency

The study area has intensified and expanded with urbanization from central or capital areas to remote areas. Urban areas covered by buildings are replacing agricultural or vacant areas which represent the expansion of Pathum Thani Province and its transition of buildings and road intersections from 2007 to 2017, as shown in Figure 4. It presents the allocation of the economic centres of the province, described as a dense area of mixed residential and commercial buildings. Furthermore, several shopping malls are located nearby the main highway to attract huge demand of trip generations. In addition, there are several multi-modal connectivity transfer points or terminal areas to connect for travelling abroad by air transport. As well as, it is also provided a service for the regional connection of northern and northeastern trips, passing through the area to the capital city.

However, looking at the activity nodes and intersections in 2017, it reveals the city's growth over the past ten years. The centre of the city or economic agglomeration areas presents the same area located at the main highway junctions. Moreover, within the urban growth process, it can be observed that the building settlement has spread from the city centre with no direction as a scattering pattern. It demonstrated that rather than expanding to the area near the boundary with the Bangkok area, the direction of expansion was far away from Bangkok to the area of Pathum Thani province. Regarding the development of transpor-

Year	Population	No. of Household	Population density	In-migration	Out-migration	No. of employment (Formal)	No. of employment (Informal)	Year	Growth rate						
2012	1,033,837	489,783	677.55	93,342	73,620	322,014	145,773	2012	-	-	-	-	-	-	-
2013	1,053,158	506,671	690.21	83,407	70,688	306,302	152,481	2013	1.87	3.45	1.87	-10.64	-3.98	-4.88	4.60
2014	1,074,058	521,360	703.91	84,176	70,121	614,590	275,187	2014	1.98	2.90	1.98	0.92	-0.80	100.65	80.47
2015	1,094,249	551,271	717.14	81,024	68,255	608,816	291,124	2015	1.88	5.74	1.88	-3.74	-2.66	-0.94	5.79
2016	1,111,376	567,974	728.36	80,360	68,189	647,332	272,910	2016	1.57	3.03	1.57	-0.82	-0.10	6.33	-6.26
2017	1,129,115	585,814	739.99	78,314	66,614	623,490	273,294	2017	1.60	3.14	1.60	-2.55	-2.31	-3.68	0.14
2018	1,146,092	603,834	751.11	81,170	69,346	610,587	304,508	2018	1.50	3.08	1.50	3.65	4.10	-2.07	11.42
2019	1,163,604	624,930	762.59	86,883	72,689	608,673	308,130	2019	1.53	3.49	1.53	7.04	4.82	-0.31	1.19
2020	1,176,412	642,474	770.98	85,358	70,053	670,986	275,399	2020	1.10	2.81	1.10	-1.76	-3.63	10.24	-10.62
2021	1,190,060	660,020	779.93	76,097	64,846	755,565	187,811	2021	1.16	2.73	1.16	-10.85	-7.43	12.61	-31.80

Figure 3. Socioeconomic profile of study area

a. Number of buildings in 2007

b. Number of buildings in 2017

c. Road intersections in 2007

d. Road intersections in 2017
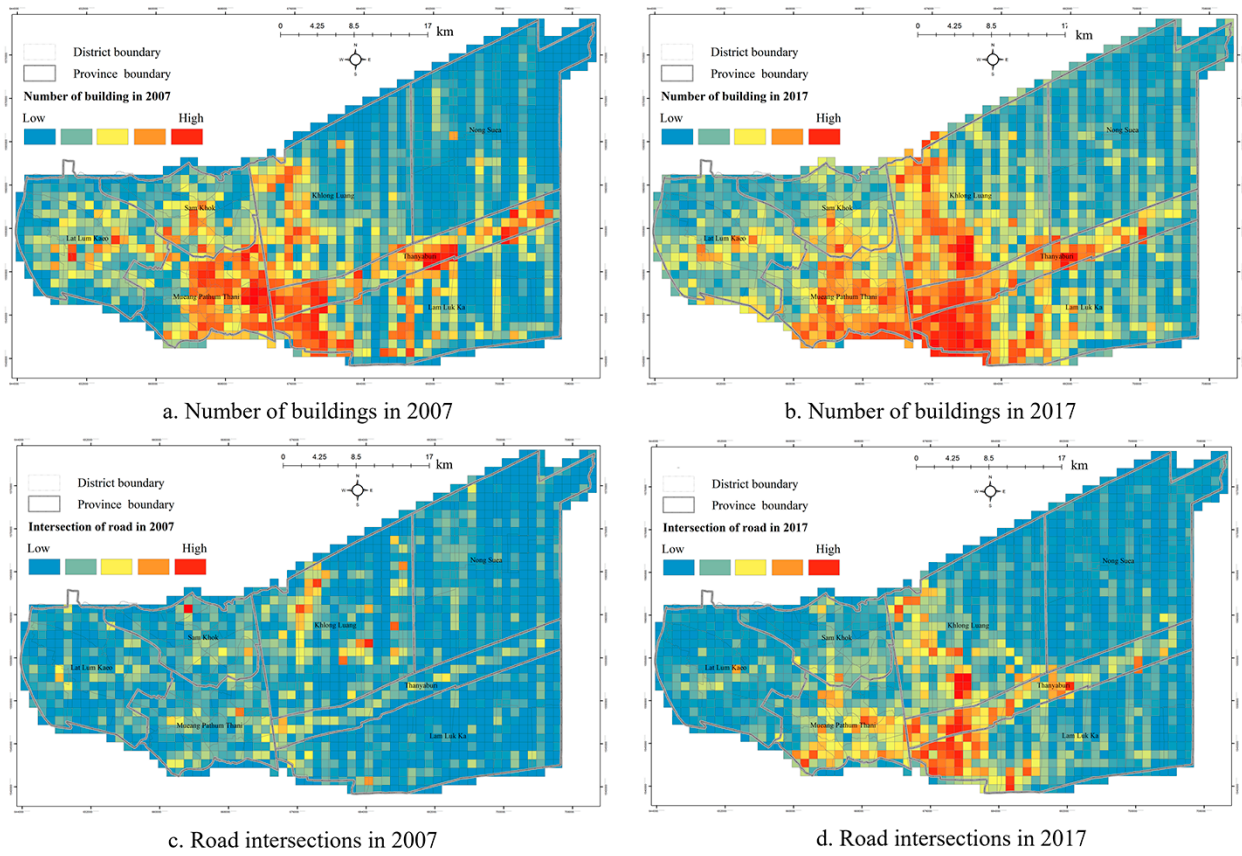
Figure 4. Changes of buildings and road intersection between 2007 and 2017

a. Level of accessibility to local road

b. Level of accessibility to main road

c. Level of accessibility to public transport
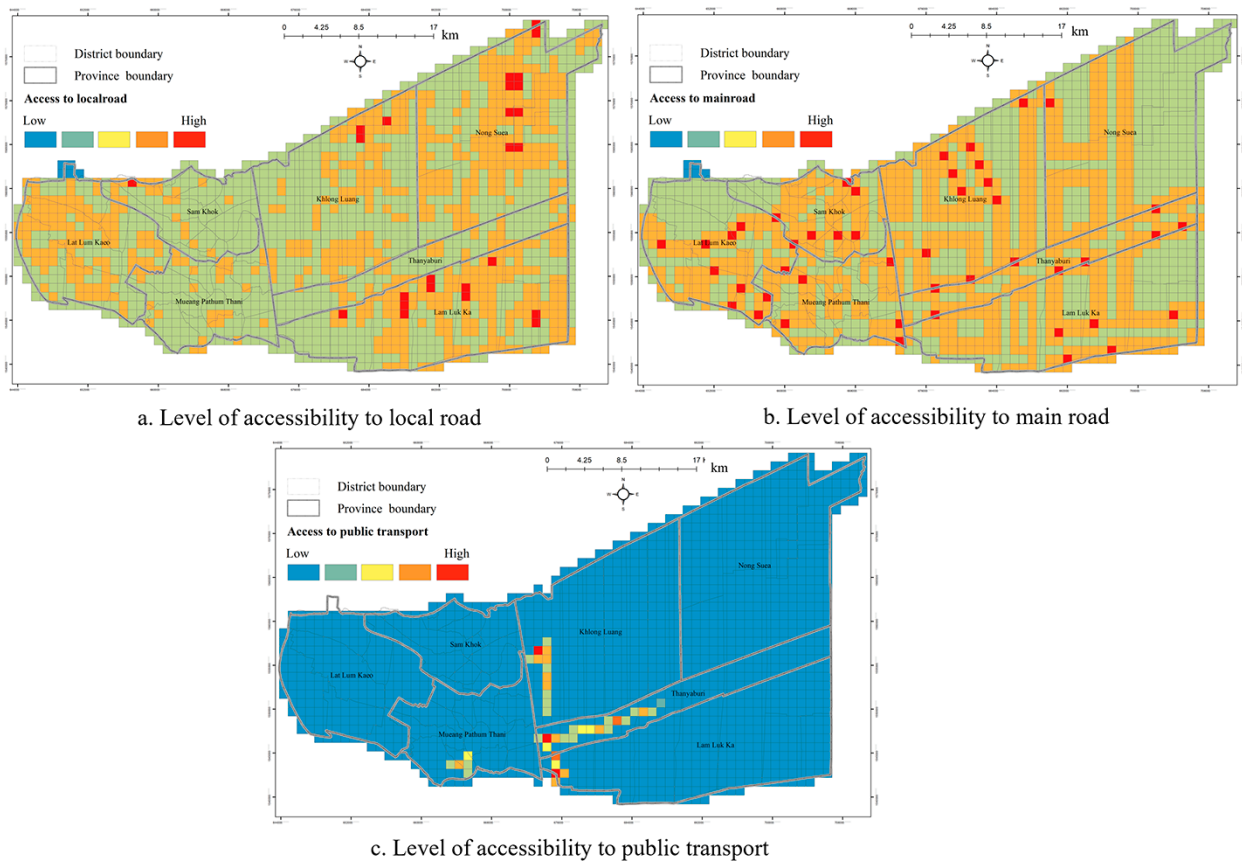
Figure 5. Level of public transportation accessibility

a. Number of commercial buildings

b. Number of institutions

c. Number of mixed use buildings

d. Number of recreations

e. Number of industrial buildings

d. Number of residential buildings
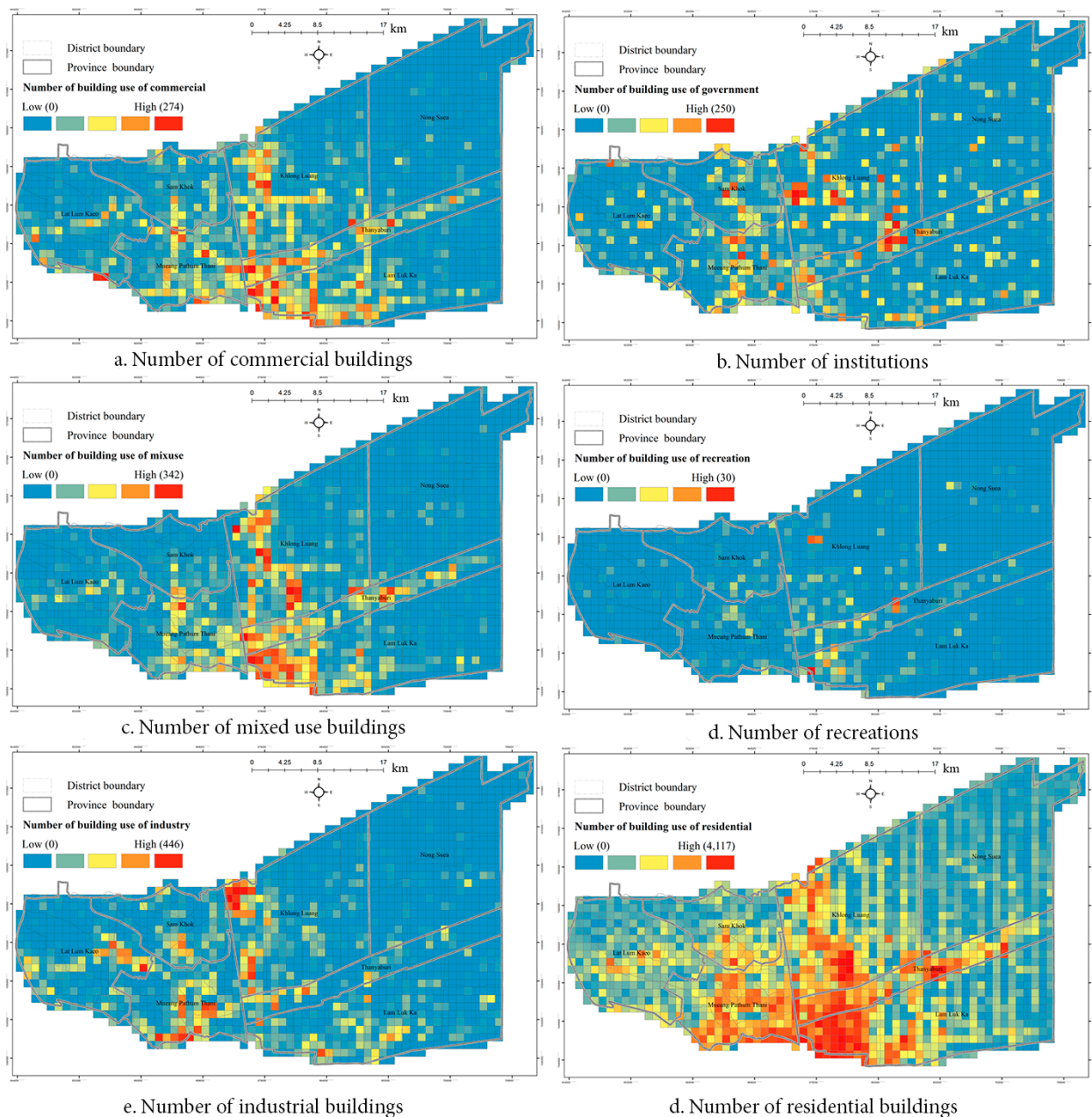
Figure 6. Characteristics of building activities

tation networks and transportation systems, it demonstrates that the substantial expansion of highway networks to support the travelling demand of the population, while public transport development was found its constrain and the availability in terms of service area is mainly limit only within the city center area (as shown in Figure 5). Thus, the urbanization process could be triggered by the restriction of public transport development which is slower than the city's expansion rate. This certainly leads to car dependency in this suburbanized area, making private cars the primary mode of transportation.

Socioeconomic profile and commuters' behavior with car despondency

Based on the results of the questionnaire analysis which was conducted in this part, this research attempts to explore the correlation between socioeconomic, travel behaviour, and mode choice to provide better understanding among the factors associated with car dependency in areas. Table 1 shows a correlation between the respondent profile and travel behaviours. The analysis of the sample data of 1,998 people showed that most of respondents were male (50.8%) with the age category of 26-30 years old (26.8%), followed by 31-35 years old (25.0%) and 36-40 years (15.7%). Most of the educational levels were

a bachelor's degree (60.0%), followed by a high school degree/vocational certificate (17.6%) and a vocational certificate (15.5%). For the average income of the respondents, it was found that the average personal income per month per person of the sample group falls within 20,000-25,000 baht (30.5%), followed by an income level of 25,001-30,000 baht (28.4%), and income level 30,001–35,000 baht (13.0%). When socioeconomic factors were considered, it was found that all factors were statistically significant at the 0.05 level of significance. It exhibited that different socioeconomic characteristics were significant for using the different travel modes. Regarding travel behaviour, the respondents had a vehicle in possession of more than 89.1% of which most of which were personal cars, followed by motorcycles. The car ownership of preliminary data presents their travelling patterns of Pathum Thani as dependent on a personal vehicle by

Table 1. Respondent profile

Variables	Private		Public transit		Paratransit		Total		P-value
	n	%	n	%	n	%	n	%	
Gender									
Male	939	93.5	41	4.1	24	2.4	1,014	50.8	
Female	851	89.7	51	5.4	47	5.0	978	48.9	0.018*
Others	6	100.0	0	0.0	0	0.0	6	.3	
Age (years)									
Lower than 20	20	62.5	6	18.8	6	18.8	35	1.8	
21 to 25	121	90.3	7	5.2	6	4.5	140	7.0	
26 to 30	471	89.5	25	4.8	30	5.7	536	26.8	
31 to 35	458	93.7	20	4.1	11	2.2	499	25.0	
36 to 40	279	90.6	22	7.1	7	2.3	314	15.7	0.000*
41 to 45	227	92.7	9	3.7	9	3.7	245	12.3	
46 to 50	146	98.0	1	0.7	2	1.3	153	7.7	
Older than 50	74	97.4	2	2.6	0	0.0	76	3.8	
Education level									
Junior high school level	8	80.0	1	10.0	1	10.0	10	.5	
High school or vocational school level	272	89.5	19	6.3	13	4.3	309	15.5	
Diploma or occupational school level	342	97.4	5	1.4	4	1.1	351	17.6	0.000*
Bachelor's degree	1,049	90.0	67	5.8	49	4.2	1,199	60.0	
Higher than a bachelor's degree	125	96.9	0	0.0	4	3.1	129	6.5	
Occupation									
Student/university students	30	63.8	9	19.1	8	17.0	52	2.6	
University staff	2	100.0	0	0.0	0	0.0	2	0.1	
Workers in a private company	842	89.0	58	6.1	46	4.9	975	48.8	
Shopkeeper or shop owner	480	97.2	5	1.0	9	1.8	495	24.8	0.000*
General employed	412	93.8	20	4.6	7	1.6	443	22.2	
Housekeeper	0	0.0	0	0.0	1	100.0	1	0.1	
Others	30	100.0	0	0.0	0	0.0	30	1.5	
Income level (average income per month per person, THB)									
5,001 - 10,000	43	97.7	1	2.3	0	0.0	45	2.3	
10,001 - 15,000	139	90.3	9	5.8	6	3.9	158	7.9	
15,001 - 20,000	187	88.6	2	0.9	22	10.4	211	10.6	
20,001 - 25,000	517	88.1	52	8.9	18	3.1	610	30.5	0.000*
25,001 - 30,000	528	94.6	21	3.8	9	1.6	568	28.4	
30,001 - 35,000	240	92.7	6	2.3	13	5.0	260	13.0	
More than 35,000	142	97.3	1	0.7	3	2.1	146	7.3	

one person owning more than one vehicle either car or motorcycle. However, when the modes of transportation that commuters choose to use were considered, the results were focused on three types of mode utilization (private cars and public transport, and paratransit).

According to the data, most commuters adopt their personal vehicles (personal cars, motorcycles, bicycles, etc.) as their main mode of travel, representing more than 89.9 percent. It is consistent with the number of personal vehicle possessions by more than three-fourths of all travellers. Travelling by bus is followed by 4.6%, and paratransit accounts for 3.6%. In terms of traveling time, it was found that over 41.6% of travel times are less than 15 minutes, indicating that such travels are short trips within the area. When travel

behaviour factors were considered, it was found that all factors were statistically significant at the 0.05 level of significance. Therefore, it can be confirmed that different travel behaviour characteristics were significant in terms of the differences in travel mode selection. The respondents' profiles and travel behaviour are presented in graphic visualization for a clear understanding, as illustrated in Figure 7.

Furthermore, this study also analysed the explanatory variables in different travel behaviours of suburban commuters. The result of Table 2 presents the significant finding of the socioeconomics of commuters leading to the selection of transportation mode choices which the decision makers must comprehend for the appropriate policy options and sustaining the transportation problem of the study area.

Table 2. Respondents' travel behaviors

Variables	Private		Public transit		Paratransit		Total		P-value
	N	%	N	%	N	%	N	%	
Travel time (minutes)									
< 15	715	89.4	45	5.6	40	5.0	832	41.6	0.000*
15-30	631	92.4	24	3.5	28	4.1	690	34.5	
31-60	446	94.7	23	4.9	2	0.4	471	23.6	
> 60	4	80.0	0	0.0	1	20.0	5	0.3	
Vehicle possession									
Yes	1,670	95.8	51	2.9	23	1.3	1,781	89.1	0.000*
No	126	58.6	41	19.1	48	22.3	217	10.9	
Trip purposes									
Studying	29	61.7	10	21.3	8	17.0	52	2.6	0.000*
Working	1,030	91.0	65	5.7	37	3.3	1,154	57.8	
Dining and eating	254	94.4	12	4.5	3	1.1	276	13.8	
Shopping	232	89.9	4	1.6	22	8.5	260	13.0	
Leisure and recreation	251	99.2	1	0.4	1	0.4	256	12.8	
Total	1,796	89.9	92	4.6	71	3.6	1,998	100.0	

The level of significance was set at p < 0.05 for the analyses.
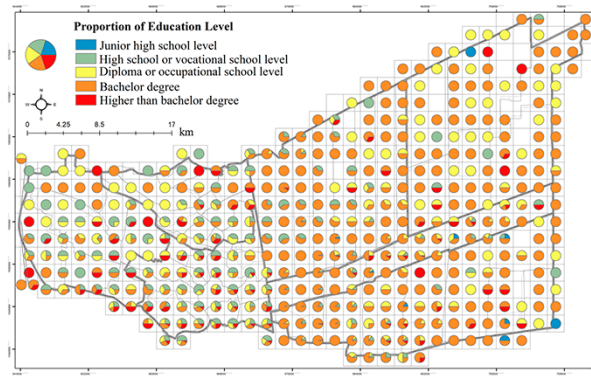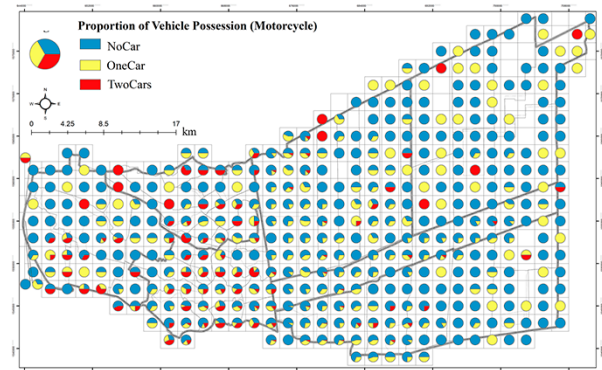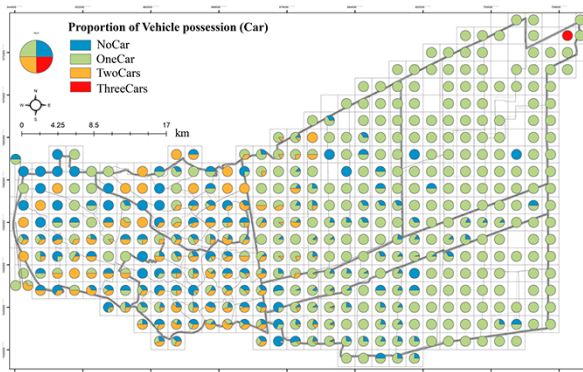
a. Proportion of education level
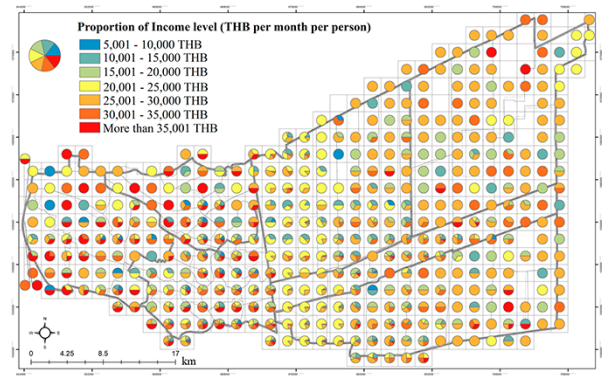
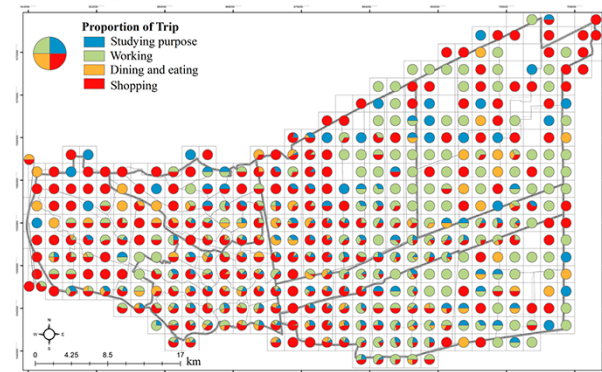b. Proportion of income level (THB per month per person)
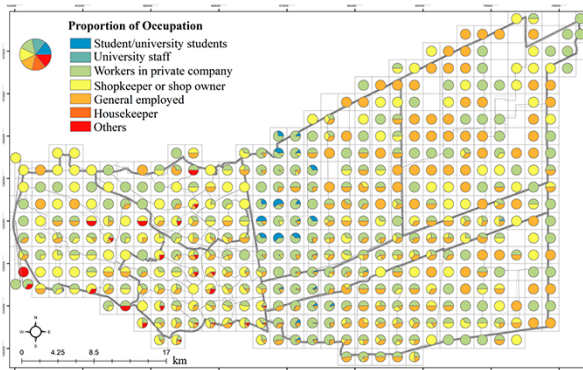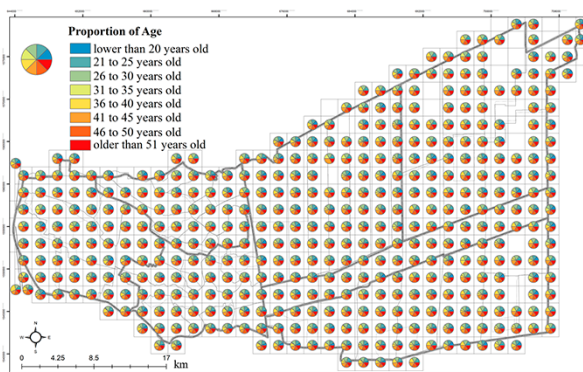
c. Proportion of occupation

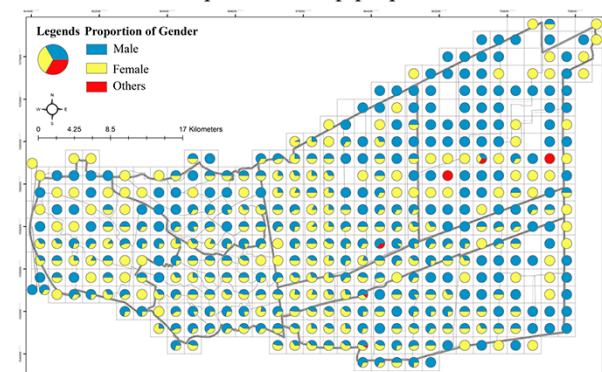d. Proportion of vehicle possession (motorcycle)

e. Proportion of vehicle possession (car)

f. Proportion of trip purposes

g. Proportion of age distribution

h. Proportion of gender

Figure 7. Respondent profiles and their travel behaviors

Discussion

Car dependency is one of the significant problems and challenges among urban and transportation planners. Several studies have indicated that numerous factors contributed to the support of travelling by private vehicles instead of public transport or other forms of active transportation modes. Although there are more alternative forms of traveling within the city, private vehicles are the most needed. Therefore, passenger cars have been dominant on most street networks. This result of study indicated that car dependency for travelling is not only related to the nature of the travel behaviour of commuter in suburban area, but the social and economic characteristics also influenced due to the pattern of urban development (e.g., efficiency and accessibility of public transport, road development pattern, etc.). The socio-economic factors were primary factor in choosing a mode of travel at the individual level, where the sample group with a high education level and income often used a personal car. Furthermore, travel time and trip purposes were also significant for choosing the mode of travel as the subjects of choosing private cars due to saving time and convenience in travelling, especially for longer network trips.

When considering on the physical characteristics of urban and transportation characteristics, the direction of urban development in Pathum Thani Province is noticeable different in terms of intensity and variety of land use activities and transportation systems within their spatial aspect. The center area is full of intense density and there is a variety of activities in terms of nodal of activities and urban services, e.g., large shopping centers, hospitals, clusters of small shopping centers, as well as the concentration of housing. Regarding the transportation system in the city center, it is also available to serve both public and para-public transport systems, transshipment points for freight and passengers among various modes of travel within the area. On the other hand, the peri-urban area is significantly less dense and diverse in terms of concentration of activities than other urban centers. Most scattered developed areas are in the form of agricultural and low density housing, including small commercial activities. As for the transportation systems supported in this area, most travelling patterns are by private vehicles and para-public transport due to the available network of public transport is inaccessible.

However, Pathum Thani Province play a role as an area that supports expansion of urbanization of capital of Thailand. As a result, most of the areas are full of prime residences that support suburbanization. These residential areas are located next to the business cent-

ers or between several sub centers and its periphery. Therefore, at the location of diversity and concentration of activities, the connectivity supported by public transport systems are available only at the urban core or main urban function or centers which causes a large amount of travel volumes to create trip pattern of private vehicles. Given that commuting pattern, car dependency has become the main problematics of mobilization among suburbanization area of urban development which is also confirmed by Litman (2002) about the influencing factors from transport and land use associations. In addition, among a variety urban problems and issues, a sustainable development approach is taken as the core of strategic planning and development by focusing on balanced development in social, economic, and environmental dimensions (Hassan & Lee, 2015). The situation of relying on private vehicle must be tackle to balance with the dimension of social and environmental due to causing the adverse effects of climate change, negative health issues, and social inequalities (Li & Zhao, 2017; Frederick et al., 2018; Al-Hinti et al., 2007). Therefore, efforts to create sustainability in transportation systems must be considered by creating alternative solutions to alleviate traffic congestion while diminishing the need for private cars. Several approaches are adopted, such as developing public transport systems prioritizing, improving safety, connectivity and accessibility, and promoting affordability and non-motorized travel development through appropriate infrastructures and facilities allocation with friendly urban design to promote daily non-motorized travel. Based on this research approach, it can provide valuable message to help reduce the dependence on private cars by capturing commuters' behavior in associated with urban spatial configuration which can help to lead for recommending the development policy to be consistency with the national goals. Such an approach, it would particularly helpful at planning and policy due to the country 20-year strategic plan for transport and transportation development (2018-2037), target for transport and transportation development in the issue of creating equitable and equitable access to transport systems through design and implementation services for all. In order to pay attention to the development of public transportation with the aim on reducing the dependence on private vehicles, the target should lead to the transport behaviors changes to effectively reduce the traffic on the roads from the origin trips at the vicinity of Bangkok.

Findings arising from this study appeal to the impact of association between urban and transporta-

tion systems development that consequent ty car dependency in sub-urbanized area of Pathum Thani Province. However, there were also study limitations related to the factors within the consideration of research framework. Due to the dependency on personal vehicles, many studies in the past have deliberated several factors to provide multi-dimensional reflections among land use patterns among several context of road network in different specific requirements within diverse group of individuals and communities. In addition, further studies should improve the format of the input data based on rigorous verification and validation. Currently, several research in land use and transportation has been applied information techniques related to technology and innovations, e.g., Augmented Reality (AR), Virtual Reality (VR), GPS, mobile applications, etc., which helps to make precise and real-time informed decisions with large databases. However, considering the large amount of data requirement to produce more realistic reflections of diverse commuters' behavior, lack of data availability together with traditional data collecting process could not be sufficient in capturing the real performance of urban structures while restrain the significant reflection based on commuters' socioeconomic characteristics, opinions and needs of representations among diverse group of travelers in the area. Therefore, the study results are more or less in extraction the current problematics in driving the development of a sustainable transport system policy and planning. Finally, the development of urban and transportation systems must be focused on more than just infrastructures or physical considerations. Moreover, the needs and compatibility of the commuters' behavior must be contemplated due to the reason that trip making decision in terms of modal usage are influenced by several factors involved in any particular traveling context within different capacity of urban configuration. Notably, a plan for reducing the number of private vehicles and enhancing sustainable development must be realistic while the considering among the multi-dimensional of social, cultural, and economic including tangible and intangible must be comprehended.

Conclusion

This paper aims to study the challenges of sustainable mobility in the context of car dependency in suburban areas in Thailand. This study leverage information relating to the socioeconomic and physical profile of the study area, like physical characteristics, socioeconomic profile, and travel behaviour of respondents, to consider the challenges of sustainable mobility in car dependency. The findings of the analysis pinpoint car dependency are not a single aspect; that includes numerous factors that are affected. Importantly, it highlighted the challenges of sustainable urban and transport development due to the results pointing to a developmental asymmetry; the development of public transport in the study area is slower than the city's expansion rate. This leads to car dependency in this suburbanized area, making private cars the primary mode of transportation.

Thus, city planners, urban designers, and policy decision-makers should have to look at the comprehensive view of maintaining the pace of transport infrastructure development with the support of inclusive commuting behaviours in their city. Recommendations for reducing dependence on personal vehicles should focus on public transport and personal mobility, including putting in place significant feeder investments to support the implementation of main public transport and active mobility, etc. Though this study has some limitations in input factors needing to be more comprehensive in all relevant factors, these findings can be extended, leading to sustainability in developing transportation and transportation systems in the future for suburban areas.

Acknowledgments

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