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The Role of Paratransit to Support Sustainable Transportation: Case Study of Khon Kaen City, Thailand

Pattamaporn WONGWIRIYA ^{a*}, Fumihiko NAKAMURA ^b, Shinji TANAKA ^c,
Ryo ARIYOSHI ^d, Shino MIURA ^e

^a Lecturer, Faculty of Architecture, Khon Kaen University, Khon Kaen 40002, Thailand

^b Executive Director, Vice President, Yokohama National University, Yokohama 240-8501, Japan

^{c,d} Associate Professor, Graduate School of Urban Innovation, Yokohama National University, Yokohama 240-8501, Japan

^e Assistant Professor, Graduate School of Urban Innovation, Yokohama National University, Yokohama 240-8501, Japan

Abstract

Considering the transport system in Thailand, there are various transport modes including paratransit. Primarily, Songtaew or a modified pick-up truck in Thailand operates as a dominant public transport mode in many medium-sized cities. However, there is a lack of empirical study regarding the role of Songtaew service to support sustainable transportation. Therefore, the primary goal of this study is to motivate a modal shift to public transit towards the sustainable transport system. The policy deliberation is based on an evaluation of the Songtaew service regarding the institutional side, supply side, and demand side. Implications of this study would also be useful for providing data on developing countries' paratransit issues for further research on paratransit as well as for contributing to sustainable transportation.

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1. Introduction

Currently, paratransit which is informal public transport is a dominant urban public transport mode in developing countries, especially in Thailand where has various types of paratransit such as motorcycle-taxi, Tuk-tuk, Songtaew,

* Corresponding author. Tel.: +66-62-496-4561; fax: +66-43-362-047.

E-mail address: pattamawong@kku.ac.th

and Silor-lek. Mainly, Songtaew or a modified pick-up truck taking passengers on the back with an overhead cage and two-row seats in the back that can accommodate up to 18 passengers or more, operates as a primary public transport mode in many medium-sized cities of Thailand (Wongwiriya et al., 2016).

Studies regarding paratransit in Thailand are mainly concerned with issues such as the role of paratransit focusing on service characteristics, service quality and user satisfaction with the service, especially in the Bangkok area. This study is the first attempt to focus on the role of Songtaew service in the medium-sized cities in Thailand focusing on all sides which are the institutional side, the supply side, and the demand side. The results could be useful for identifying problems and suggesting the recommendation to improve Songtaew service which is a popular mode in the city and particular for passengers who have a limitation on mode choice selection. However, there is a lack of empirical study regarding the role of Songtaew service to support sustainable transportation and the survey on Songtaew service in Thailand have not yet well understood.

Therefore, the primary goal of this study is to motivate a modal shift to public transportation towards the sustainable transport system by investigating the Songtaew service system and the use of Songtaew in Khon Kaen City, Thailand.

This paper begins by providing the background and motivation of the study, followed by the overview of Khon Kaen City and Songtaew in Thailand, and the data and methodology. Then the findings regarding Songtaew analysis in terms of the institutional side, the supply side, and the demand side were explained. Finally, the paper concludes with the role of Songtaew to support the sustainable transport system and the policy consideration, and implications for the developing countries.

2. Background and motivation

These days the transport situation in many developing countries including Thailand changes quite rapidly especially an increasing number of private vehicles. The use of public transport in Thailand tends to decrease, and the automobile tends to increase. The problem with individual vehicle-dependent societies lies with its enormous impact on the environment and the quality of life in many urban areas. This study addresses the challenge of planning and creating an urban transportation system that considers social aspects, environmental quality, and economic development. In other words, our challenge is to create a sustainable transport system.

Since the percentage of the urban population of the total population has been increasing continuously in Thailand, rising from 29.4% in 1990 to 44.1% in 2010 (Social Statistic Bureau, 2011). The urban population growth forced the cities to expand into rural areas. This situation of the urban areas has resulted in an increased need for mobility. The mobility of goods and people is an essential part of all social and economic activities. One of the transportation problems in developing countries is how to provide mobility services for all segment of the community. Besides the challenge of providing mobility services in the cities, the lack of public transportation and traffic congestion are also the major problems of the developing country cities.

The primary cause leading to traffic congestion is the high number of the vehicle, private transportation, which was caused by population growth and economic development. Reducing the number of cars on roads and improving transportation infrastructures are essential ways to reduce the traffic density in the urban area. However, the reduction in the vehicles, especially private vehicles that constitute the majority will not be possible unless the public is provided with an option for accessibility, affordable, convenient and quality public transport.

Acknowledging the challenging nature of a sustainable transport system, this research investigates the potential of paratransit namely Songtaew in Thailand which is the primary urban transport mode in many medium-sized cities to improve sustainability within an urban transport system. Considering the paratransit system in Thailand, there are various paratransit modes.

Nowadays paratransit plays a role as the dominant urban public transport mode in many developing countries, especially in Thailand where has various types of paratransit such as motorcycle-taxi, Tuk-tuk, Songtaew, and Silor-lek. Especially, Songtaew or a modified pick-up truck taking passengers on the back with an overhead cage and two-row seat in the back that can accommodate up to 20 passengers, operating as a primary public transport mode in many medium-sized cities of Thailand was selected as a case study in this research. Although new transportation modes have been introduced in some medium-sized cities such as Khon Kaen, Phuket, Chiang Mai, and Nakhon Ratchasima. Songtaew services remain the primary public transport mode in many cities even in the suburban areas of Bangkok as a feeder of the Mass transit system.

Focusing on Songtaew, in cities especially in the regional capitals and medium-sized cities of Thailand, Songtaew operates as a main urban public transport which is served areas along the main and the local streets with a fixed route. According to the future planning for urban public transportation in medium-sized cities of Thailand, Khon Kaen, Chiang Mai, and Nakhon Ratchasima are interested and in the process of Bus Rapid Transit (BRT) planning and also Light Rail Transit (LRT) planning. The feasibility studies have been already studied in those cities, but only Khon Kaen City has been in the process of detail design of BRT and LRT (Jaensirisak et al., 2013). Therefore, this research is focusing on the role of Songtaew in Khon Kaen City where there are the studies only about the new transport mode, BRT, and LRT, and the preparation progress of those new transport modes is fastest among the other cities. However, the existing urban transport mode, Songtaew, in Khon Kaen city has not been studied about the possibility of Songtaew service continuing in the future yet, especially the studies related to its role in Khon Kaen urban transport and its user perception (Jaensirisak et al., 2013).

Another significant issue concerns with the study of Songtaew is it has not yet well understood especially the issues related to the possibilities of a Songtaew system in supporting sustainable transportation. This study is the first attempt to focus on all the institutional side, the supply side, and the demand side of Songtaew system in Thailand. Since Songtaew is a unique transport mode that its service is a small scale, a flexible service. Moreover, Songtaew is legal service since its operation has to be licensed by the Land Transport Department of Thailand. This research examined the regulation related to Songtaew and investigated the Songtaew service system by considering the supply side of Songtaew and the use of Songtaew from the demand side by investigating the travelers and drivers' point of view to understand better about its service system and the factors that influence this mode use. Admittedly, it is crucial to evaluate Songtaew system to understand various aspects of the paratransit system as mentioned previously.

Therefore, this study would be useful to Khon Kaen City as well as other medium-sized cities in developing countries to motivate more public transportation use in the future and to assure the citizen that they can "leave their car behind" for driving modal shift and contributing to sustainable transportation.

3. Overview of Khon Kaen City and Songtaew in Thailand

Khon Kaen City is centrally located in the north-east region of Thailand. Its total area is 46 square kilometers as shown in Fig. 1. The city is home to 326,643 people (in 2014) where has known as the center of economic, education, traffic and urban development in the north-east region part of Thailand. Moreover, Khon Kaen City has the polycentric pattern of employment and education centers that allow people to make many trips around the city.

Songtaew in Thailand is modified from a pick-up or a larger truck with two rows of seats in the back carrying about 20 passengers. At present, Songtaew provides passenger movement in both within towns and cities and for longer routes between cities and villages. In Bangkok Songtaew plays a role as a feeder of mass transit system especially bus, train, the Metropolitan Rapid Transit (MRT) and the Bangkok Mass Transit System (BTS). (Tangphaisankun, 2010) For the transportation in other cities especially in the primary cities of different regions in Thailand, Songtaew plays a role as the main public transportation in urban and rural areas (Kikuchi et al., 2013) as shown in Fig. 2.

In Thailand, there are two main types of Songtaew related to its design and vehicle as shown in Fig. 3. The first type of Songtaew is some vehicles are modified from Toyota Dyna, Mitsubishi Fuso Canter, Isuzu Elf and similar large trucks which can accommodate more than 30 passengers and operates as a fixed - route bus to run on the fixed route between province area connecting the rural and the urban area through the different parts of Thailand.

The second type of Songtaew is some vehicles which are modified from a pick-up truck such as Toyota Hilux, ISUZU D-MAX, ISUZU D-LUX, etc. This type of Songtaew can accommodate more than 20 passengers and operates as a fixed-route bus to run on the fixed route in Bangkok both downtown and suburb, urban and rural areas in other provinces especially in the primary cities in the different regions of Thailand.

Based on the authors' field survey conducted in August 2015 about the existing Songtaew service as can be seen in Table 1, there is a total of 19 Songtaew service routes operated in Khon Kaen City. It can accommodate up to 20 passengers on any trip. Moreover, a flat-fare system is used, with adults costing 9 Baht and students costing 5 Baht. In Khon Kaen City, Songtaew is usually modified from a pick-up truck such as Toyota Hilux, ISUZU D-MAX, and ISUZU D-LUX as shown in Fig. 3 (the right side). It operates by the private sector and local cooperative as hail and ride service on fixed-route in the city.

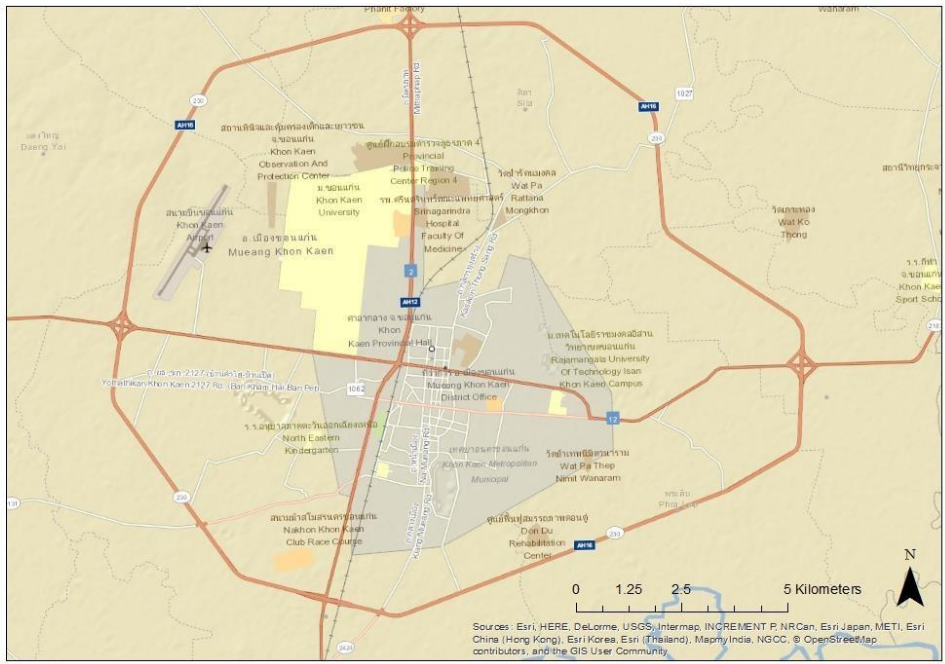


Fig.1. Khon Kaen City Map
Source: Wongwiriya et al., 2017.

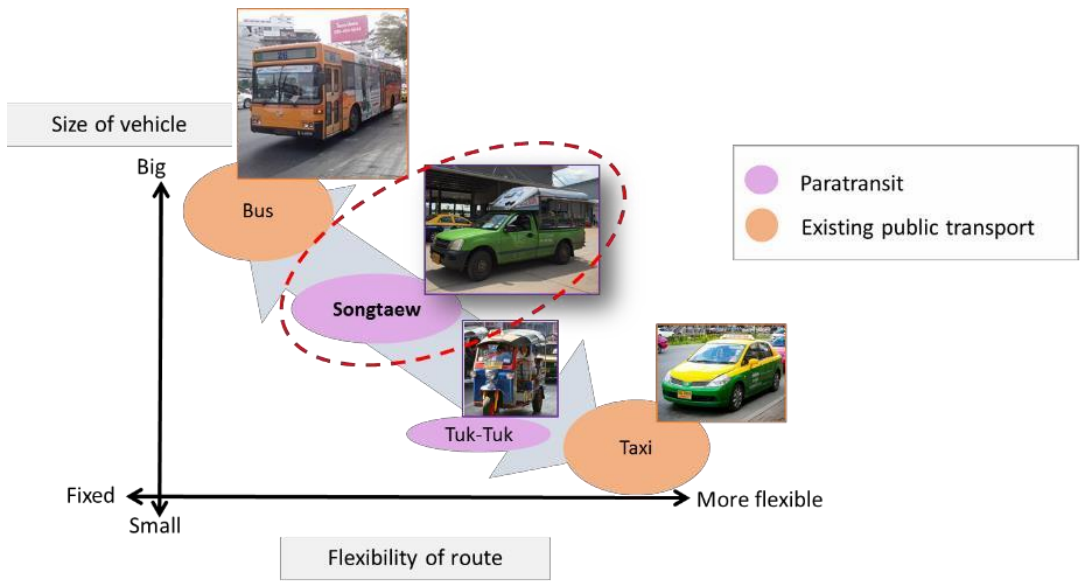


Fig.2. Songtaew definition in terms of the size of vehicle and flexibility of route
Source: Adapted from Hirabayashi et al., 2013. (Wongwiriya et al., 2017.)



Fig.3. The various design of Songtaew

Table 1. Basic information on Songtaew in Khon Kaen City.

Elements	Values
Number of Route	19
Vehicle capacity (person/vehicle)	20
Average travel time (one way) (h)	0.50
Average Route Length (km)	18
Fare (per person per trip)	0.27 USD (9 THB: Adults) 0.15 USD (5 THB: Students)
Operation time	6:00 AM – 6:00 PM

Source: Field survey conducted in 2015. (Wongwiriya et al., 2017.)

4. Data and methodology

The methodological framework was developed to achieve the main goal of research which is a modal shift in providing policy development and recommendation to improve the paratransit service in Khon Kaen City. Firstly, a review on paratransit, especially in developing countries focusing on all institutional side, supply side and demand side of the paratransit system, had been done to better understand the paratransit studies. Secondly, the investigation regarding the regulation and policy of Songtaew had been done by both a literature review on the previous research on this issue. Next, the supply side analysis was conducted by focusing on the Songtaew service performance regarding the study of the supply side characteristics especially cost characteristic analysis. After that, the demand side analysis was focused by 1) analyzing the existing travel behavior of travelers in Khon Kaen City both Songtaew user and non-user, 2) examining the Songtaew perception by analyzing travelers' satisfaction on Songtaew service, and 3) investigating travel choice behavior and the influence of Songtaew service on Khon Kaen urban commuting. Then, the role of Songtaew in Khon Kaen City to support sustainable transportation is detailed. Finally, the significant factors in explaining Songtaew ridership are revealed. Then the recommendation regarding essential policies and the improvement of operating performance and future management would be developed to support the sustainable transport in Khon Kaen city, notably contributing to a modal shift.

To study both the supply and demand side of Songtaew service, the questionnaire was developed. Especially for the demand side studies, the author analyzed results from a comprehensive field survey conducted among Songtaew

users and non-users in Khon Kaen City, to measure their perception of the service provided. The investigations were carried out on interviewing randomly selected passengers in the Central Business District (CBD) of Khon Kaen city. Then data were analyzed through percentage, cross-tabulation, Chi-square statistical techniques and multiple regression analysis for examining the Songtaew perception for the users, the non-users, and the drivers. Moreover, for the study of travel mode choice behavior, the multinomial logit model of regular trips in Khon Kaen City is developed to analyze the mode choice behavior.

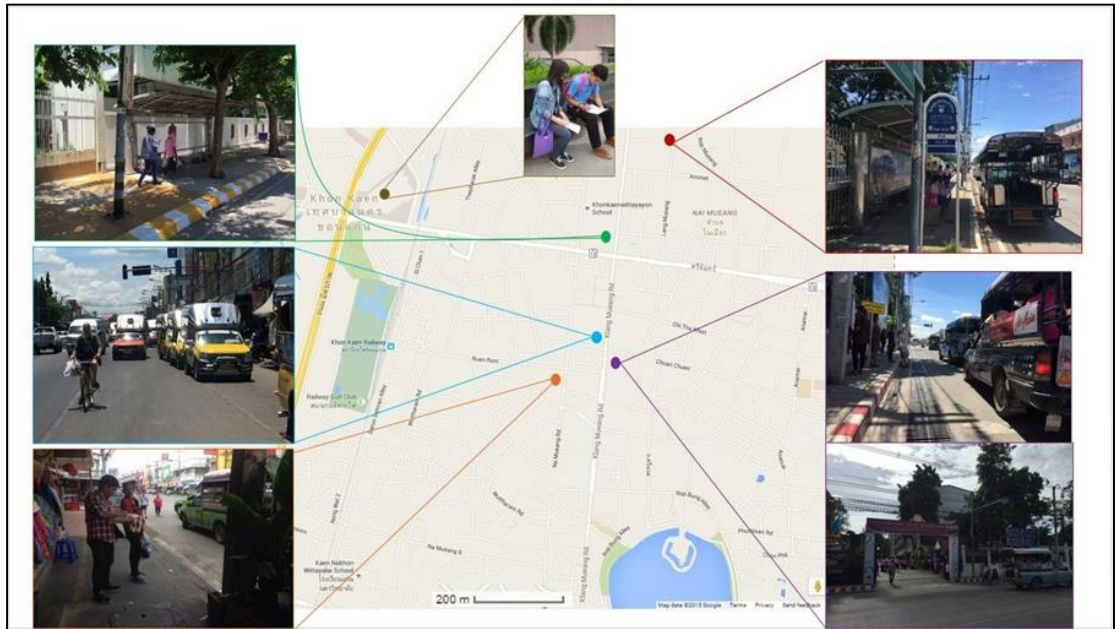


Fig.4. Field Survey and Data Collection in Khon Kaen City

The originality of the methodological approach adopted for this research is given by the integrated evaluation of three main aspects of the paratransit system; institutional, supply and demand sides. Furthermore, to encourage the widespread use of Songtaew, it is essential to understand the multifaceted issue of trip satisfaction, and its implication for travel behavior in Khon Kaen city. Another originality of this research is to increase user satisfaction should be better understand about users' perception regarding the service from both the users and also from the drivers of Songtaew. Since users' perceptions are affected by the performance of the attributes of the service provided by the drivers. Thus this study also focused on differentiating between the users and drivers' perception regarding the provided service, since users' satisfaction requires the experience of the service, while the drivers are responsible for providing the service by supplying users to their destinations. To put in other words, the drivers are responsible for making users' experience through their provided service.

Furthermore, the drivers' service is affected by their perception as well. Therefore, it is needed to investigate the drivers' perception, not only the users' perception to seek whether they have different perceptions or not. If we could know the different perceptions of them, it would be able to recommend the improvement of the service they offered by bridging these differences to meet the users' need for providing the most satisfaction to the users to retain the existing users in the future.

5. The institutional side of Songtaew focusing on the regulation

Thai central government is responsible for public transportation in Bangkok and other provincial areas, which includes the Office of Transport and Traffic Policy and Planning, and the Department of Land Transport. To regulate policy of fixed-route bus as well as Songtaew in Thailand is implemented under Land Transport Act 1979 (B.E. 2522)

by having Land Transport Policy Committee, Central Land Transport Control Board (CLTCB) and Provincial Land Transport Control Board (PLTCB) that have the authority to fix the routes, the number of Songtaew operator, and the number of vehicles for fixed routes in Bangkok and other provincial areas. (Department of Land Transport, 2014)

There are two types of fixed-route bus as well as Songtaew in Thailand that operated by government agency and by private agency which is a) Government agency which is two agencies to operate bus transport: The Transport Company Limited and the Bangkok Mass Transit Authority (BMTA) are state enterprises that the government shareholder is 51%, and private shareholder is 49%. The Transport Company Limited is permitted to operate the route which links between Bangkok and other provinces. The Bangkok Mass Transit Authority (BMTA) is permitted to operate the routes which are in Bangkok Metropolitan area, and b) Private agency which is approved by the government to manage the bus and Songtaew in the bus route in Bangkok Metropolitan area, the municipalities and the village in the provincial areas. (Department of Land Transport, 2014)

The fare-setting process is defined in the acts. The CLTCB has the authority to fix the share rates of transportation and other service charges. Those charges are determined by referring to the discussion in the cabinet. The fare of the urban bus, as well as Songtaew, is calculated under the cost-plus pricing, which determines the fare based on the estimated total cost. Section 23 of the 1979 Local Transport Act presents the licenses by route and by vehicle size which related to Songtaew is the license of the fixed-route transportation is valid for seven years while the licenses of the non-fixed route and small-vehicle transport are valid for five years. The provincial board gives these licenses under the Ministerial regulation.

6. The supply side of Songtaew focusing on cost analysis of the current operation

Depending on the availability of detailed data, the performance of Songtaew route number 8 which is the primary route plying thoroughfare of Khon Kaen city has been selected for this study. It is useful to analyze operating costs by considering the critical components of Songtaew operating costs, namely personnel, energy, and maintenance to figure out the influencing factors which affect the cost structure of Songtaew service. Unfortunately, no data relating to personnel component is available for Songtaew service at the time of this research. However, Songtaew drivers usually own Songtaew fleets and run their service. The payment for drivers is based on the number of passengers per day. For investigating the performance of Songtaew by the collected and secondary data, cost analysis in terms of operational performance is undertaken in the following sequences.

In order to obtain the Songtaew route number 8's density in terms of average values of Songtaew fleets per kilometer, route length was calculated, and its result shows that the current density of Songtaew route number 8 is 2.67 number of Songtaew per kilometer. Moreover, from the collected data, the waiting time per unit of songthaew route number 8 can be analyzed in terms of average values of travel time per kilometer route length, and its result shows that the current waiting time per unit of Songthaew is 4.17 minutes. However, the waiting time is one of the important factors for evaluating the performance of the Songtaew service, the performance of Songtaew is still poor, especially in the real situation the waiting time is unreliable depending on the drivers such as some drivers stop the vehicles at each stop taking too much time to wait for the more passengers.

Operational performance of Songtaew service based on cost analysis has been studied to investigate the factors that might be affecting Songtaew performance. According to the limitation of available data relating to detailed Songtaew's cost structure, the results show that not only energy prices that affect the cost of Songtaew providing in Khon Kaen City but drivers' driving practice is also the influencing cost elements of Songtaew costs. Also, the analysis of Songtaew costs points out that Songtaew using LPG is considerably providing lower cost than Songtaew using CNG and diesel. Therefore, changing fuel consumption has a significant impact on the sustainability of the operation in the future. Furthermore, it is possible to introduce the Songtaew service as effective transportation which continues growing and still play a significant role in the city more than other public transport vehicles such as motorcycle taxis, car taxis, and three-wheelers because of its advantages on accessibility and low-cost service.

As a result, we can consider that operating costs of Songtaew in Khon Kaen City has affected by not only energy costs and maintenance costs, but there are other exogenous variables which can affect costs of this mode such as drivers' salary, operating speed, road condition, maintenance standard, loading practices, vehicle capacity, and vehicle age.

Table 2. The summarization of Songtaew cost characteristics in Khon Kaen City.

Types	Characteristics
Operating costs	- Driver's wage per day ranged from 300 Baht to 400 Baht
Maintenance costs	- Fuel costs ranged from 200 to 500 Baht per day The average of Songtaew maintenance costs (such as tires, oil, and repairs) ranged from 5,000 Baht to 9,600 Baht.
Fixed costs	Licensing fee, registration fee, and other taxes which the average of paying the total fees is 1,500 Baht per unit.

Furthermore, for contributing to the sustainable transportation in Khon Kaen City, the results in this section highlighted that the operating cost using LPG and CNG is much lower than using diesel then towards the sustainable transportation in the city should encourage the Songtaew drivers to use LPG or CNG. Although, LPG releases CO₂ which is a greenhouse gas, it is cleaner when compared to gasoline. Moreover, CNG releases lesser greenhouse gas. Therefore, this encouragement would contribute to the sustainable transportation of Khon Kaen City.

Lastly, due to the difficulty encountered in collecting data for this section, the government should require Songtaew owners to submit basic financial reports for making Songtaew database available for conducting the research and developing the policy relating to improving Songtaew performance in the future.

7. The demand side focusing on the travel behavior of travelers in Khon Kaen City

The study in this section revealed that the highest share of transport mode in Khon Kaen City is Songtaew. However, considering about the intention to use Songtaew in the future from which are if there will be a new transport mode for users and if there will be the improvement of Songtaew revealed that the choice users (37%) and the choice non-users (42%) are the majority groups who intend to keep using and stop using Songtaew (the users) and who intend to shift their modes from private vehicles to Songtaew (the non-users). Moreover, the consideration about the loyalty users who want to keep using Songtaew in the future, it revealed that 78.6% of the Songtaew users expressing their attitude toward still using Songtaew in the future even there will be a new transport mode like Bus Rapid Transit (BRT) or Light Rail Transit (LRT).

Considering the result regarding the travel behavior pattern, it can be summarized as follows. The results showed that people with higher income mostly lived in the CBD area and made more travel than people with low income. The most of the home-based trip in Khon Kaen City is work trip which most of the workers took Songtaew going to their destination more than other modes

The relationship between the travel behavior pattern and city structure also was examined in this study. The results show that people with higher income mostly lived in the CBD area and made more travel than people with low income. The most of the home-based trip in Khon Kaen City is work trip which most of the workers took Songtaew going to their destination more than other modes.

Moreover, it is clear from the study that the city structure of Khon Kaen City which is the polycentric pattern of employment and education centers, along with the dispersal of many jobs and schools outside the CBD. This creates more trips outside the CBD, especially for the people who live in the Outer CBD Fringe and Rural-Urban Fringe areas, with the shorter travel time than the people who travel for a work trip and school trip in CBD area. Moreover, the accessibility by Songtaew is usually convenient for people who travel in the CBD because of the congestion and the lack of parking space in CBD area that halts some car users to drive cars in CBD. The results of this section could potentially aid in applying urban transportation policy in the future.

8. The demand side focusing on the perception of paratransit in Khon Kaen City

According to journey to school in Khon Kaen City, the satisfaction of Songtaew service result indicated that the students who use Songtaew for going to school in Khon Kaen City have different satisfaction. This different satisfaction was found among the students who always use Songtaew and the others who usually use motorcycle but

sometimes using Songtaew regarding the characteristics of them such as gender, age and the status of holding the driving license. The overall satisfaction reflects that generally, all student users are satisfied with Songtaew service because of the cheap fare and the convenience of the service. Moreover, the reliability and comfort have a strongly significant effect on the non-users on the decision for not using Songtaew.

Turning to summarize the journey to work in Khon Kaen City, the finding of the perception for the users indicated that the fare of Songtaew which is cheaper than other modes, and the convenience of the service had a significant effect on the Songtaew users' satisfaction. Turning to the perception for the non-users, the results also explained the factors which are the cost, the availability, the waiting time, the safety and the comfort are the crucial factors which had a significant influence on their perception for not using Songtaew.

Lastly, based on the examination regarding the perception of the drivers and users on factors related to the usage of Songtaew: safety, reliability, comfort, and flexibility. The results indicated that there is a significant difference perception between Songtaew drivers and users in Khon Kaen City. Moreover, the result highlighted that reliability and flexibility had strongly a positive impact on the decision to commute by Songtaew for both drivers and users' perception. This result is very interesting. Although there is no Songtaew schedule, and sometimes they have to wait for Songtaew more than 5 minutes, but they still perceive Songtaew service is reliable especially in CBD area because there is a high frequency of Songtaew service in CBD area. Thus, the waiting time around 5 to 10 minutes can be acceptable for them, and they could predict their arrival time at their destination from their travel experience. For the safety issue, it is also interesting to find that it might be not only the safety issue relating to driver behavior, but the waiting area at Songtaew stop also might affect their perception on the safety issue.

However, some of the respondents raised the safety issue that there are some Songtaew waiting area problems currently occurring such as missing route information and no properly design of Songtaew waiting area especially at the crowded space in CBD. These results in discomfort and discourages people to use Songtaew as well as to increase the risk of a safety issue.

9. The demand side focusing on the travel mode choice behavior in Khon Kaen City

According to this analysis, travel cost, travel time, safety condition of the transport mode and individual characteristics have considerable effects on Khon Kaen City travelers' travel choice. Based on the estimated model, it can be concluded that travel cost, travel time, safety condition of the transport mode should be the policy variables which are influencing people in Khon Kaen City selecting their travel mode choice. Considering the encouragement of reducing private vehicles' dependency in the city to support sustainable transportation in Khon Kaen City. The policy plan for Khon Kaen Transportation Development to encourage more Songtaew use is needed following the findings of this study.

Regarding model results, more travelers would shift to Songtaew if shortening the travel time, reducing the travel cost and increasing the satisfaction of safety issue. Thus, the reduction of the travel time of Songtaew service which means all the waiting time and the in-vehicle time would significantly enhance the possibility of the Songtaew service chosen by people in Khon Kaen City. In conclusion, this section analyzed the travelers' choice behavior through discrete choices model in Khon Kaen City. The cost, travel time, safety and driving license possession were the essential variables that have a significant impact on the travel choice behavior in the city. Some recommendation was provided after identifying the influence of these factors on the selection model results. Such as improving the Songtaew service by shortening the travel time including the waiting and in-vehicle time, enlarging transit service coverage areas and increasing the safety issue primarily control the drivers' driving behavior. The fare of Songtaew is already acceptable since cheaper than another mode. However, it should not be set too high in the future. Because of the median and low-income people tend to choice Songtaew to make their trip. Moreover, it is necessary to enhance the connection with the new public transport mode which will be proposed to the city in the future to form the role of Songtaew and integrate with the other modes such as the feeding of the passengers. If all the recommendation policies can be carried out together, this can lead the car and motorcycle users to select public transportation which is Songtaew and improve the choice probability of public transit as well as to support the sustainable transportation and make Khon Kaen City is more sustainable in the future.

10. The role of Songtaew to support the sustainable transport system

A sustainable transport system must provide mobility to all urban residents with safe and environmentally friendly modes of transport. For example, if the population cannot afford to use private motorized transport, they have to use public transport mode to their destination. Therefore public transportation should be provided with a safe infrastructure and good quality service.

As stated, Songtaew is the primary mode of public transport in the city that has consistently served the residents of Khon Kaen City over time. In the meantime, the number of private vehicles increased rapidly. In Khon Kaen City, in particular, the lack of quality public transport resulted in phenomenal increases to the number of private vehicles on the road. In the eyes of the public, these factors further decreased the competitiveness and the need for the improvement of Songtaew. In addition, its drivers are untrained, and its operations are not strictly regulated. These aspects contribute to reducing the significance of Songtaew to a marginal transport service predominantly for people who have an access limitation to other vehicles, and people who are unable to drive as well as to non-local people such as the tourist.

This investigation of the role of Songtaew in Khon Kaen City may reflect only part of the reality, but it attempts to provide an insight into the service and a viable choice to the car and motorcycle.

It is widely accepted that the provision of quality public transport promotes sustainable transport. Some past studies have been done to identify a suitable form of public transport for the city. Implementation of BRT and LRT system have been proposed as an appropriate form of public transportation for Khon Kaen City. Despite numerous plans, public consultations and approval of budgets, these systems have not been implemented yet due to various factors including the lack of the study of existing public transport mode, Songtaew.

As previously mentioned, setting the objectives towards sustainable transport is needed. In this section, a list of objectives necessary to achieve the vision previously defined is made which supported by Songtaew service study from this research. There are three main categories of the purposes: 1) Protection of the environment, 2) Quality of living standard and 3) Economy which adapted and modified from Minken et al., 2003. These three objectives and the suggested actions and policy considerations regarding the results of this research can be shown in Table 3.

Basic goals for policy and planning to support sustainable transportation is the reduction of car use for daily mobility, strengthen non-motorized and efficient public transport (Prillwitz, 2011). Concerning the decrease in private vehicle use and the encouragement of Songtaew use in Khon Kaen City, many previous studies noted that the quality of public service is the most crucial aspect to attract people to shift their mode. Thus, it is essential to improve the service of Songtaew to support sustainable transportation in Khon Kaen City. Considering the results found from this study, sustainable transportation in Khon Kaen City depends on:

- (1) Promote the use of Songtaew which is the main public transport mode.
- (2) Reduce Greenhouse gas by encouraging Songtaew drivers to use LPG or CNG.
- (3) Songtaew service improvement by considering factors tending to identify significant individuals to use ST which are the Travel cost, Travel time, Image of ST, and Safety.
- (4) Integrating ST as a feeder of LRT or city bus service in the plan by connecting the people to use LRT or city bus on the main route's service.
- (5) Utilizing the existing public transport mode; Songtaew by improving ST service which will save city money more than building the new transport mode.

Moreover, how to make the quality of transportation service which is satisfactory to users and comparable to alternative modes of travel is necessary to support the city sustainability especially in the sustainable transportation context.

Besides the results from this study, the critical factors towards sustainable transportation are (Tumlin, 2012):

- 1) Speed: Reducing travel time (especially on the busiest routes in the city center) is essential, not just to reduce travel times, but also to improve the reliability of the service and reduce operating costs.
- 2) Frequency: Operating more frequency will attract more choice riders.
- 3) Passengers Experience: In addition to time, people value their comfort, convenience, safety, and money.

Table 3. Khon Kaen City sustainable transport planning supported by Songtaew.

Aspect	Objective	The suggested actions and policy considerations
Environmental	Environment protection	<ul style="list-style-type: none"> Promote the use of Songtaew >> Less dependence on the private vehicle. Reduce Greenhouse gas >> Encouraging the ST drivers to use LPG or CNG.
Social Equality	Improve public transport quality to promote its use for all travelers in the city	<ul style="list-style-type: none"> ST service improvement >> Considering factors tending to identify significant individuals to use ST which are the Travel cost, Traveltime, Image of ST, and Safety. Integrating ST as a feeder of LRT or city bus service in the plan >> Connecting the people to use LRT or city bus on the main route's service.
Economy	Promote efficiency economy	<ul style="list-style-type: none"> Utilizing the existing public transport mode; Songtaew by improving ST service >> Saving city money more than building the new mode.

Source: Adapted and modified from Minken et al., 2003.

In this case, public transportation must compete with private vehicles by increasing safety, providing all-day, or evening service, providing secure waiting areas, providing the cleanness of stops and vehicles, providing more coverage service areas, providing service information including clear signs and clear and widely schedule and map, especially for the city center with busiest routes, and providing real-time information for passengers especially on personal communication devices.

11. Policy consideration for Songtaew service

It is apparent that the transport system of Khon Kaen City is highly unsustainable; it is highly dependent on car and motorcycle, which produce harmful emissions and cause the traffic congestion, the injuries, and death from transport accidents.

Over recent years there have been several proposals for the implementation of various public transport systems in Khon Kaen City, ranging from introducing the BRT and the LRT services in and around the city following major arterial routes. However, there is a lack of understanding that the city needs to find a solution to its congested roads by understanding more about the existing urban public transport mode. What seems to be lacking is the political will to actively improve the current transport system and pave the way toward a more sustainable future. Therefore, improving our ability to understand the realities of the existing urban transport system and find practical solutions to facing problems is needed for contributing to sustainable transportation.

Thus, this study seeks to increase the chances of successfully solving urban transport problems and improving the sustainability of the system through the case study of Songtaew in Khon Kaen City.

The study regarding paratransit system in Khon Kaen City covered all institutional side, supply side and demand side which can develop possible policy implications, which serve as useful information for transportation planners in formulating an appropriate policy and regulation for the sustainable and efficient integrated public transport system in Asian developing countries. Furthermore, studies on paratransit should also be done in other Asian developing cities. Due to the differences in city characteristics, the operations of paratransit might not be the same and policy implications might follow.

11.1. The suggested actions and policy considerations

According to the results, the recommended actions and policy considerations for Songtaew service are:

- 1) Implement a diverse route and balanced coverage service areas that meet the transportation needs of everyone in the city.
- 2) Improve the coordination among Songtaew service operators to integrate the public transit system in terms of the physical, and operational system.
- 3) Build the necessary infrastructure and facilities such as Songtaew stops, Songtaew information signs, Songtaew schedule to extend the quality of service of Songtaew in the city.
- 4) Give priority to road-based public transit mode, Songtaew, to other modes especially cars to reduce the delay of Songtaew as well as the travel time such as Songtaew express lane in rush hour.
- 5) Improve the Image of Songtaew service by improving the quality of service to meet the expectation of the majority riders especially on the safety and image issues such as promoting ST driver education.
- 6) Provide incentives to Songtaew operators for operating a reliable service of choice to riders.
- 7) Penalize or disqualify the Songtaew operators from operating the service if they fail to provide a reliable and quality service regularly.
- 8) Provide real-time information mainly on the busiest routes for passengers especially on personal communication devices to reduce the waiting time of Songtaew.
- 9) Reduce Greenhouse gas by encouraging Songtaew drivers to use LPG or CNG.

11.2. The policy development

Considering the policy development from this study, the proposed policy developments to support sustainable transportation in Khon Kaen City can be divided into two main policies.

(1) Land use development policy

- Ease of accessibility improvement policy

Enhancing the linkage between land use and the existing public transport service, ST, by implementing a diverse route, and balanced coverage service areas especially the house communities areas that meet the transportation needs of everyone in the city to encourage the car and motorcycle users shift their mode to Songtaew.

(2) Transport development policy

(2.1) Utilizing the existing public transport mode: Songtaew service improvement policy

- Reduce total travel time
- Improve the safety of the service
- Improve the image of Songtaew

(a) Provide real-time information mainly on the busiest routes for passengers especially on personal communication devices to reduce the waiting time of ST.

(b) The enforcement and regulations of service license and good behavior driving training should be implemented.

(c) Improving the good design and the cleanliness both inside and outside of the vehicle and facilities at the Songtaew stop.

(2.2) Integrating Songtaew with new public transport services

- Integrating Songtaew as a feeder of LRT or city bus service in the future plan

(a) Songtaew rerouting that it can reach as close as possible to the LRT station or obtain well coordination with the city bus network.

(b) Implementing coverage service areas especially on the narrow routes inside the city to connect the people to use LRT or city bus on the main route's service that meets the transportation needs of everyone in the city in the future.

Admittedly, Songtaew in Khon Kaen City plays an vital role to support sustainable transportation in the city. The usage of public transport which is Songtaew can be promoted by improving the service of Songtaew in Khon Kaen City as mentioned previously. Primarily it should be focused on the improvement of reducing travel time, increasing the frequency of service, expanding the coverage service area, and increasing the satisfaction of users experience especially safety issue. Moreover, it is also crucial for the city to integrate urban transportation planning and land use

planning. Therefore, it should be studied more about the integration of Songtaew service planning and Khon Kaen City land use planning in the future.

Implications of this study would also be useful for the other researchers to understand more about the factors which affect the paratransit use in other cities. Furthermore, this study would also help provide data of developing countries' paratransit issues for further research on paratransit in other developing countries.

12. Conclusions

It is evident from the above mentioned in this study that reducing the private vehicle use in the city and enhancing the use of public transportation by reducing the adverse impact on the environment is one of the dominant approaches towards the sustainable transportation. As transportation is related to everyone's daily life, transportation service is one of the variables on which the quality of life of residents in a city depends. A sustainable transportation system can ensure that it is an aspect of livability and thus sustainable transportation improves the quality of life in the city.

One of the primary goals of sustainable transportation is to reduce the travel demand, especially reduce the trips made by private vehicles. To achieve this, the city should start diverting from designing private vehicle oriented cities to public transport friendly cities. Thus, Songtaew in Khon Kaen City plays an important role to support the sustainable transportation in the city since Songtaew is the main mode of public transport in the city that has consistently served the residents of Khon Kaen City. About the reduction of private vehicle use and the encouragement of Songtaew use in Khon Kaen City, the results noted that the quality of public service is a crucial aspect to attract people to shift their mode. According to this research, the usage of public transportation which is Songtaew can be promoted by improving the service of Songtaew in Khon Kaen City primarily focusing on the improvement of travel time, coverage service area, and the satisfaction of users experience especially the image and the safety issues of Songtaew. Moreover, it is also crucial for the city to integrate urban transportation planning and land use planning. Therefore, it should be studied more about the integration of Songtaew service planning and Khon Kaen City land use planning in the future.

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References

- Bacero, R.S. and Vergel, K. (2009). Assessment of Jeepney's components, systems, and separate technical units for the development of standards. Proceedings of the 17th Annual Conference of the Transportation Science Society of the Philippines.
- Cervero, R. (1992). Paratransit in Southeast Asia: a market response to poor roads?. *Review of Urban and Regional Development Studies*, 3, 3-27.
- Cervero, R. and Golub, A. (2007). Informal Transport: A Global Perspective, *Transportation Policy*, Vol. 4, Issue 6, 445-457.
- Chen, L., Yang, F., Cheng, Y., Yao, Z. and Zhang, X. (2014). Urban Public Transport Choice Behavior Analysis and Service Improvement Policy-Making: A Case Study from The Metropolitan City, Chengdu, China, TRB 2014 Annual Meeting.
- Diaz, C.E.D. and Cal, P.C. (2005). Impacts of Government regulation on the sustainability of paratransit services in the Philippines: Case of FX services between Manila city and Quezon city. *Journal of the Eastern Asia Society for Transportation Studies*, 6: 214-224.
- Dimitriou, H.T. and Gakenheimer, R. (2011). *Urban Transport in the Developing World: A Handbook of Policy and Practice*. Edward Elgar Publishing, Massachusetts.
- Guillen, M.D., Ishida, H., Okamoto, N. and Tsutsumi, M. (2007). Public transportation policies and the road-based public transport service in developing countries: the case of indigenous public transport modes in Davao City, Philippines. *Proceedings of the Eastern Asia Society for Transportation Studies*, 6.
- International Association of Traffic and Safety Sciences. (2015). *Traffic and Safety Sciences: Interdisciplinary Wisdom of IATSS*.

- Jaensirisak, S., Klungboonkrong, P. and Udomsri, R. (2013). Development of Bus Rapid Transit (BRT) in Khon Kaen, Thailand, Proceedings of the Eastern Asia Society for Transportation Studies, 9.
- Jittraphirom, P. (2015). An analysis of Chiang Mai city's transport system and its path towards sustainability, with a focus on the role of the motorcycle and the shared-taxi. Doctoral Thesis, Vienna University of Technology.
- Joewono, T.B. and Kubota, H. (2005). The characteristics of paratransit and non-motorized transport in Bandung, Indonesia. Journal of the Eastern Asia Society for Transportation Studies, 6: 262-277.
- Joewono, T.B. (2007). User Perceptions of Private Paratransit Operation in Indonesia, Journal of Public Transportation, 10 (4): 99-118.
- Kikuchi, H., Fukuda, A., Ishizaka, T., Ito, H. and Satiennam, T. (2013). Possibility to realize low carbon city in the medium-sized city of Asia: case study in Khon Kaen city, Thailand. Proceedings of the Eastern Asia Society for Transportation Studies, 9.
- Loo, B.P.Y. (2007). The role of Paratransit: some reflections based on the experience of residents' coach services in Hong Kong, Transportation, 34: 471-486.
- Minken, H., and May, A. (2003). Developing Sustainable Urban Land Use and Transport Strategies: A Methodological Guidebook.
- Oshima, R., Fukuda, A., Fukuda, T., and Satiennam, T. (2007). Study on regulation of motorcycle taxi service in Bangkok. Journal of the Eastern Asia Society for Transportation Studies, 7, 1828-1843.
- Prabnasak, J. and Yue, W.L. (2006). Using aaSIDRA and PARAMICS in the evaluation of a traffic signal coordination development in Khon Kaen City, Thailand. ATRF06: 29th Australasian Transport Research Forum.
- Rahman, M.S. (2012). Public transport in a small island of a developing country, Brazilian Journal of Urban Management, Vol.4, No. 1, pp. 61-72.
- Satiennam, T., Jaensirisak, S., Natevongin, N. and Kowtanapanich, W. (2011). Public transport planning for a motorcycle Dominated Community. Proceedings of the Eastern Asia Society for Transportation Studies, 9, 970-985.
- Shimazaki, T. and Rahman, Md. M. (1996). Physical characteristics of paratransit in developing countries of Asia: Transportation in Asia-Pacific countries. (Volume1), Journal of Advanced Transportation, Vol.30, No.2, pp. 5-24.
- Simon, D. (1996). Transport and Development in the Third World, Routledge, New Fetter Lane, London.
- Sustainable Infrastructure Research and Development Center. (2016). Feasibility study for a public transportation system for Khon Kaen City, Khon Kaen University.
- Tangphaisankun, A. (2010). A study in integrating paratransit as a feeder into mass transit systems in developing countries: a study in Bangkok. Doctoral Dissertation, Yokohama National University.
- Tumlin, J. (2012). Sustainable Transportation Planning, John Wiley & Sons Inc., Hoboken, New Jersey.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Sanit, P., Ariyoshi, R.: Paratransit in Developing Countries: Songtaew in Thailand, Proceedings of the Eastern Asia Society for Transportation Studies, Vol.10, 2015.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Ariyoshi, R.: The Role of Paratransit in Thailand Considering the Cost of Songtaew in Khon Kaen City, Proceedings of the International Symposium on Urban Planning, 2015.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Miura, S., Ariyoshi, R.: User Perception of Paratransit in Developing Countries: A Case Study of Songtaew in Khon Kaen City, Thailand, Proceedings of the International Conference of Asian-Pacific Planning Societies, 2016.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Ariyoshi, R.: User Satisfaction of Songtaew in Thailand: Case Study of Khon Kaen City, Journal of Transportation Research Procedia, ELSEVIER, Vol. 25C, pp. 4946-4953, 2017.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Miura, S., Ariyoshi, R.: User Perception of Paratransit in Thailand: Case study of Journey to Work in Khon Kaen City, Asia-Pacific Journal of Science and Technology, VoL. 22, Issue: 02, 2017.
- Wongwiriya, P., Nakamura, F., Tanaka, S., Miura S.: The Pattern of Travel Behavior in Khon Kaen City, Proceedings of the Eastern Asia Society for Transportation Studies, 2017.