Using the 'Avoid-Shift-Improve' Approach to Evaluate The 12-Year Development Plan (2009 – 2020) for Bangkok's Sustainable Transportation Goals
การใช้มาตรการ ลด-เปลี่ยน-ปรับปรุง ในการประเมินผลเพื่อบรรลุเป้าหมายระบบขนส่งอย่างยั่งยืนของแผนพัฒนากรุงเทพมหานครระยะ 12 ปี (พ.ศ.2552-2563)

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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อประเมินการขนส่งอย่างยั่งยืนในแผนพัฒนากรุงเทพมหานครระยะ 12 ปี (พ.ศ.2552 – 2563) โดยใช้ทฤษฎี "ลด เปลี่ยน และ ปรับปรุง (Avoid-Shift-Improve-ASI)" เป็นกรอบในการประเมิน และเพื่อเสนอแนะแนวทางการพัฒนาเมืองให้เป็นเมืองที่มีระบบการขนส่งสาธารณะที่ยั่งยืน ผู้วิจัยใช้ระเบียบวิธีวิจัยเชิงคุณภาพ ทำการเก็บข้อมูลโดยการสัมภาษณ์เชิงลึกกับผู้ให้ข้อมูลสำคัญจำนวน 15 คน จากภาครัฐ ภาคเอกชน และภาควิชาการ ผลการศึกษาพบว่า แผนพัฒนากรุงเทพมหานครระยะ 12 ปียังไม่เป็นไปตามกรอบ ASI โดยในเรื่องลดการเดินทางที่ไม่จำเป็น (Avoid) ในทางปฏิบัติยังไม่สามารถลดการเดินทางได้ ในเรื่องการพัฒนาการใช้ประโยชน์ที่ดินและการพัฒนาพื้นรอบสถานีขนส่งมวลชนยังไม่มีการบูรณาการแผนการขนส่งกับผังเมือง และยังไม่มีการใช้ประโยชน์จากเทคโนโลยีในภาคการขนส่ง สำหรับการเปลี่ยน (Shift) รูปแบบการเดินทางนั้น มีความพยายามเปลี่ยนสู่การใช้ระบบขนส่งสาธารณะและการส่งเสริมการเดินทางที่ไม่ใช้เครื่องยนต์ (non-motorised transport) อย่างไรก็ตาม การให้บริการของระบบขนส่งสาธารณะยังคงไม่เพียงพอต่อความต้องการ ค่าเดินทางสาธารณะมีราคาแพงและขาดการเชื่อมต่อเพื่อเปลี่ยนถ่ายระบบขนส่ง ด้วยเหตุนี้การเปลี่ยนแปลงรูปแบบการเดินทางโดยใช้ระบบขนส่งสาธารณะจึงยังไม่ประสบความสำเร็จ ในเรื่องการปรับปรุง (Improve) มีการพัฒนาเทคโนโลยีที่เป็นมิตรต่อสิ่งแวดล้อมสำหรับรถยนต์ และพัฒนาพลังงานทางเลือกโดยการสนับสนุนการลดภาษีสำหรับรถยนต์ไฟฟ้าแต่ยังไม่สามารถจูงใจให้ประชาชนหันมาใช้รถพลังงานทางเลือกที่เป็นมิตรกับสิ่งแวดล้อม ผู้วิจัยมีข้อเสนอแนะจากการวิจัย 6 ประการ ได้แก่ 1) ส่งเสริมการพัฒนาพื้นที่บริเวณรอบสถานีขนส่งมวลชน 2) ส่งเสริมแนวคิดการพัฒนาเมืองแบบหลายศูนย์แบบยั่งยืน (Polycentric Cities) สำหรับกรุงเทพมหานคร 3) ส่งเสริมการวางแผนชุมชนเมืองให้มีความเหมาะสมกับระบบขนส่งสาธารณะ 4) ส่งเสริมการใช้เครื่องมือทางเศรษฐศาสตร์ เช่น การลดอัตราภาษีสำหรับรถยนต์ไฟฟ้า พิจารณากำหนดอัตราภาษีเชื้อเพลิงต่างๆ และ พิจารณาระบบตั๋วร่วม 5) กำหนดให้รถบัสในพื้นที่กทม. เป็นมาใช้รถบัสพลังงานไฟฟ้า 6) พัฒนาโครงสร้างพื้นฐานเพื่ออำนวยความสะดวกให้ผู้ใช้รถยนต์พลังงานทางเลือก เช่น สถานีอัดประจุไฟฟ้า

คำสำคัญ : การขนส่งอย่างยั่งยืน ; คาร์บอนต่ำ ; ภาคคมนาคมขนส่ง ; ลด-เปลี่ยน-ปรับปรุง ; กรุงเทพมหานคร

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ABSTRACT

This study aimed to evaluate the 12-year development plan for Bangkok Metropolis (2009–2020) and to propose recommendations for improving sustainable transportation in the city. This research conducts qualitative approach by employing in-depth interviews with 15 key informants from public, private, and academic sectors. The Avoid-Shift-Improve (ASI) approach was used as a framework to analyse the plan plan's goal to limit GHG emissions and to provide alternative mobility solutions for sustainable transport systems development. The research finding suggests that the 12-year development plan did not meet the criteria of ASI. Specifically, the avoidance of increased transportation activity was unt found. Also, jobs-housing and transit-oriented development plans were not integrated into the plan. In addition, technologies were not used to improve the transportation. On the positive side, there was a shift in the pattern of transportation to public transport and non-motorised transport. As such, however, the supply of public transportation services were under the demand. Moreover, mass transit ticket prices were considerably too high with the disconnection between the transportations' transactions. Therefore, change in public transportation's pattern was considerably unsuccessful. In terms of improvement, there was an attempt to utilize green technology to improve vehicle technology and fuel efficiency. The government also developed renewable energy for electric vehicles. The development plan also offered the tax-cut policy to attract consumers. As such, however, the policy was unsuccessful to motivate consumers using renewable energy. This research project, therefore, proposes attempt to improve existing forms of transport was ineffective. This study provides six recommendations; (1) to support the physical development projects around the building construction around the transportation office (2) to support the idea of polycentric cities' development (3) to support the suitable formation of communities planning as relevant to public transportation (4) to support the use of economic tools including tax-cut policy for electric vehicles and considering energic tax rate and common fare tickets (5) implementing policy forcing the buses in Bangkok area changing to electric vehicles (6) to develop infrastructure to support electric car users such as charging stations.

Keywords : Sustainable Transportation ; Low Carbon ; Transportation ; Avoid-shift-improve ; Bangkok

Introduction

The rapid increase in immigration in the area around Bangkok in recent decades has caused the city's extensive growth both economically and in terms of population. In 2017, the number of people in the Bangkok metropolitan area was approximately 5.68 million (Strategy and Evaluation Department Bangkok Metropolitan Administration, 2016) and the population is projected to reach 8.45 million by 2030 (Office of the National Economic and Social Development Council, 2019). Since 2007, city policies have focused on the expansion of the neighbouring provinces to support the growth of the metropolitan area. As a result, a large number of people in the five provinces neighbouring the Bangkok Metropolitan Region. Urbanisation has been considered a major driving force of the deterioration of the natural environment around the world. Similarly, to other developing countries, Bangkok's massive urban-sprawl problem is a result of the inability to balance public facilities, and zoning problems. The public transportation networks and rapid transit systems in the city's core and suburbs of Bangkok are inadequate due to the shortage of bus services, lack of public transport vehicles, unorganised infrastructure, and insufficient incentive policies (Narupiti, 2019). Consequently, the use of private cars on roads and highways has increased. The existing urban planning literature confirms that damage to the urban environment is caused by large amounts of traffic emissions,

which greatly affect people's health (ChooChuay et al., 2020 ; Vasconcellos, 2014). Road traffic contributes air pollution through a range of mechanisms including particulate matter and greenhouse gases (GHG), as well as carbon monoxide, sulphurous oxides, and nitrogen oxides (Harrison, Vu, Jafar and Shi, 2021 ; Waygood, Friman, Mitra and Olsson, 2019). There is also all around in Thailand, a continuous major air pollution problem regarding for PM_{10} and $PM_{2.5}$ caused by biomass burning and diesel vehicles during both dry and wet seasons (Dejchanchaiwong et al., 2020 ; Phairuang et al., 2019 ; Pollution Control Department, 2017). The gaseous and particulate pollutants and result in greater daily hospital admission rates for associated cardiovascular and respiratory diseases (Choo Chuay et al., 2020 ; Phosri et al., 2019).

In order to overcome urbanisation and transportation problems, the 12-Year Bangkok Development Plan (2009-2020) was established. The major goal of this plan was to achieve the "Sustainable Metropolis" through city planning policy. The plan attempts to reconcile the various problems in the city such as traffic congestion, environmental pollution, with the development of transportation networks that connect the centre of the city with all the suburbs. Furthermore, this plan aimed to increase people's awareness of environment problems and energy efficiency (Bangkok Metropolitan Administration, 2015). Although the 12-Year Plan (2009-2020) will soon be complete, many major Bangkok urbanisation problems remain in Bangkok regarding the environment and transportation. These problems include urban sprawl in the extended Bangkok area, air pollution (especially $PM_{2.5}$), GHG emissions, and traffic congestion. Through its sustainable transportation principles, the plan aims to achieve its goals over a long-term period to reduce GHG emissions, energy consumption, and congestion from transportation. The ASI approach plays a crucial role in promoting alternative mobility solutions and developing a fully sustainable transport system. As another benefit, the ASI approach has the potential to contribute to climate change management, allowing development between mitigation and adaptation. In the mitigation part, there is a focus on developing mechanisms and policies that support transport system efficiency. The adaptation part helps to define transport systems under a resilience framework that effectively manages disaster risks (Gudmundsson, Hall, Marsden and Zietsman, 2015 ; Martins, Anholon and Quelhas, 2019 ; Sustainable Urban Transport Project, 2011). Therefore, the ASI approach is a suitable framework for evaluating sustainable transportation. There is a growing need for more comprehensive research on sustainable transport in Bangkok. This study contributes to sustainable development and sustainable transportation knowledge by using the ASI approach to evaluate 12-year development plan for Bangkok Metropolis (2009-2020).

The objectives of this research were (1) to evaluate the 12-year development plan (2009-2020) by using the Avoid-Shift-Improve approach for Bangkok's sustainable transportation goals and (2) to propose recommendations to improve sustainable transportation in Bangkok. The scope of this research includes sustainable transportation of Bangkok and metropolitan based on the evaluation by Avoid-Shift-Improve Approach.

Literature Review

Sustainable Transportation

The concept of sustainable transportation has been in use since the 1980s during the same time that the concept of sustainable development was adapted across many industrial sectors. Sustainable transportation focuses on the use of more energy-efficient fuel and reducing environmental externalities of traffic such as congestion, noise, accidents, and air emissions. These concepts are described. For example. in regard to sustainable land-based transportation and the realisation of the post-2015 Development Agenda and associated Sustainable Development Goals (SDGs) (Gudmundsson et al., 2015). The essential objective

in sustainable transportation to support energy-efficient transport systems for public mass transportation systems, clean fuels, and low emission vehicles, and also the support of improved transportation systems in every area. There is also a goal in promoting an integrated approach to policymaking at the national, regional, and local levels for transport services and systems (Buckler and Creech, 2014). If developed sustainably, transport infrastructure and services can facilitate access and mobility to reduce poverty for low-income people (and provide jobs and services) thus improving their income-earning activities safely, affordably, conveniently, and equitably (Starkey and Hine, 2014).

Moreover, sustainable transportation has four principles; firstly, reduce travel needs which invokes solutions that could reduce the necessity of travel to a minimum. The important relationship between transportation and ICT is crucial. The second principle is a transport policy shift – which means that the strategy needs to change, for example by shifting from private car to walking or biking. (Ogryzek, Adamska-Kmieć and Klimach, 2020 ; Schneider, 2013 ; Vashisth, Kumar and Sharma, 2018). The third principle is distance reduction which considers shifting to environmentally-friendly transportation modes. Lastly, the fourth principle is to use technological innovation to make transport more efficient such as new engine technology, alternative fuels or renew energy sources (Fallahpour, Udoncy Olugu, Nurmaya Musa, Yew Wong and Noori, 2017).

One important consequence of the sustainable transportation idea is to consider the moral hierarchy of the traffic participant. For sustainability reasons, the privilege hierarchy should be firstly pedestrians, then cyclists, then public transport, and then private car, respectively. These ideas form a change of thinking about spatial planning which is also attractive for residents. All these participants should be involved in making decisions for transport planning (Ogryzek et al., 2020) in a representative and normative way.

Challenging Sustainable Transportation cities

The rapid growth of population poses a problem for road transportation. Most developing countries also face an imbalance between the transport infrastructures of rural and urban regions. The spatial distribution of population has also meant problem arising such as urban sprawl, environmental degradation, and poor and decaying infrastructure (Mahmood, 2018 ; Nautiyal, Malik and Agarwal, 2018). Developing countries' cities have tendency to lock-in current and historical forms of urbanization due to government decisions, commercial pressures of important industries (like mining or manufacturing) or sanctions from international relations (Antwi-Afari, Owusu-Manu, Simons, Debrah and Ghansah, 2021 ; Mfenjou, Abba Ari, Abdou, Spies and Kolyang, 2018). In the context of Thailand–the Bangkok, Nakhon Ratchasima, Khon Kaen corridor has been undergoing rapid growth in urbanisation and motorisation. Urban environment and living quality are the major problems. The government proposed a model to decrease traffic congestion and subsidies in the transportation network and an increase in the quantity and quality of the feeder systems (Sirikijpanichkul, Winyoopadit and Jenpanitsub, 2017). For other developing countries such as the African nations of Ghana, Cameroon, and South Africa, there is the common problem of a very high rate of traffic accidents and road traffic fatalities-both disproportionately high in comparison to the world average (Sukhai, Jones, Love and Haynes, 2011). The urban transportation system in these countries is challenged with a lack of quality road infrastructure, a lack of telecommunication infrastructures, and an absence of an effective system to monitoring road network activities.

However, in some Asia countries' cities which seek to achieve gains in sustainable transportation (such as Hong Kong, Singapore, Tokyo and Seoul) they focus on providing an efficient public transport system to meet public needs. From these cities, we can note effective sustainable development policies designed

to minimise vehicle trips in the urban area and an increase in pedestrian infrastructure and walkable environments. (Boakye-Dankwa et al., 2019 ; Diao, 2019 ; Lee and Palliyani, 2017 ; Rodríguez and Kang, 2020 ; Tong, 2019). Furthermore, in European countries' cities such as Paris, Berlin, Edinburgh, and Oslo were identified as cities that have been actively addressing sustainable transport issues and achieving sustainable transportation. There are strong transportation networks in these cities and a commitment to sustainability which promotes using public transportation and electric vehicles, develops cycling infrastructure, and make more pedestrian-friendly city settings. (Bauer, 2018 ; Klingen, 2019 ; Theißen and Louen, 2019 ; Yan, 2018).

Avoid - Shift and Improve (ASI) Approach

To achieve the sustainability of the transport system, the "Avoid-Shift and Improve" approach is implied for policies to limit GHG emissions in the transport sector will have to consist of a combination of measures to shift away from moving goods and people to ensuring absolute access to goods and services. The ASI approach entails three main avenues: Avoid/Reduce, Shift/Maintain, and Improve (Sustainable Urban Transport Project, 2011). "Avoid" deals with avoiding increasing transport activity and reducing travel demand. It could be achieved through better integration of land use and transport planning (Energy Sector Management Assistance Program, 2014). For example, reduction in the trip length and passenger traffic via change in the land-use patterns, high penetration of information and communication technology (ICT) and in the case of freight transport; a reduction through localisation of production and consumption activities (Dias, Simões, Gouveia and Seixas, 2019).

"Shifting" to keeping the modal share of the most efficient mode, in most of them will be non-motorised transport or public transport (Farzaneh, 2019). The critical strategy of shifting is to focus on the low carbon infrastructural choices. It assumes a significant shift towards the mass transit system, i.e., railways, metros, and buses to consume less energy.

"Improve" involves improving existing forms of transport through technological improvements to make engines and fuels less carbon-intensive. For example, improving vehicle efficiency and advanced vehicle technologies like plug-in hybrid electric vehicles and battery-operated electric vehicles (Farzaneh, 2019 ; Sustainable Urban Transport Project, 2011).

The 12-year development plan for Bangkok Metropolis (2009 – 2020)

The 12-year development plan for Bangkok Metropolis (2009-2020) under the strategic management division, the office of the strategy and the evaluation, Bangkok was setting the strategy and the long-term development of Bangkok for determining the vision and the long-term target which was the main guiding framework in developing Bangkok to be the "Sustainable Metropolis" through city planning policy. The plan attempts to reconcile the various problems in the city such as traffic congestion, environmental pollution, with the development of transportation networks that connect the centre of the city with all the suburbs. Furthermore, this plan aimed to increase people's awareness of environment problems and energy efficiency (Bangkok Metropolitan Administration, 2015). There are three phrases during 2009-2020 ; Phase I from 2009-2012, Phase II from 2013-2016 and Phase III from 2017-2020.

The objective from Vision of Bangkok 2020 as people-centric development, helping people living in well-being and environment, managing and regulation public infrastructure for good social equality. There are 5 main strategies; 1) Strengthening Infrastructure for regional Mega-City, 2) Developing Strong Economy and Knowledge-based Society, 3) Striving for Green Bangkok, 4) Providing Good Quality of life in Cultural Mega-City, 5) Mastering Best Service and Mega-City management (Bangkok Metropolitan Administration, 2015) From these strategies were important strategy related to the sustainable development. Focusing on the environmental management and consider on climate change, pollution reduction, pushing forward for every

sector (stakeholders) to join to respond for the pollution which would build instead of sole respondent and become an attentiveness on environment. There was learning to adjust the lifestyle and the behaviour. Moreover, Bangkok had accepted the Polluter Pays Principle: PPP and concern to reduce Carbon dioxide (CO2) to 15 percent within the year of 2012 from the current situation and expect population in Bangkok would reduce Carbon dioxide less than 5.5 tons per the person per year, support providing alternative transportation, etc.

Theoretical Framework

This study used the 'Avoid-Shift-Improve' (ASI) approach to evaluate the 12-year development plan for Bangkok Metropolis (2009-2020) as to whether the plan meets the criteria of sustainable transportation. The "Avoid" part deals with the avoidance of increased transport activity and a reduction of travel demand. "Shift" deals with the actions that result in shifts to modes of transports that result in less emissions. The "Improve" part deals with actions that improve vehicles and fuel performance. From this, consequently, we can then categorise how much sustainable transportation is contained within the 12-year plan.

Conceptual Framework

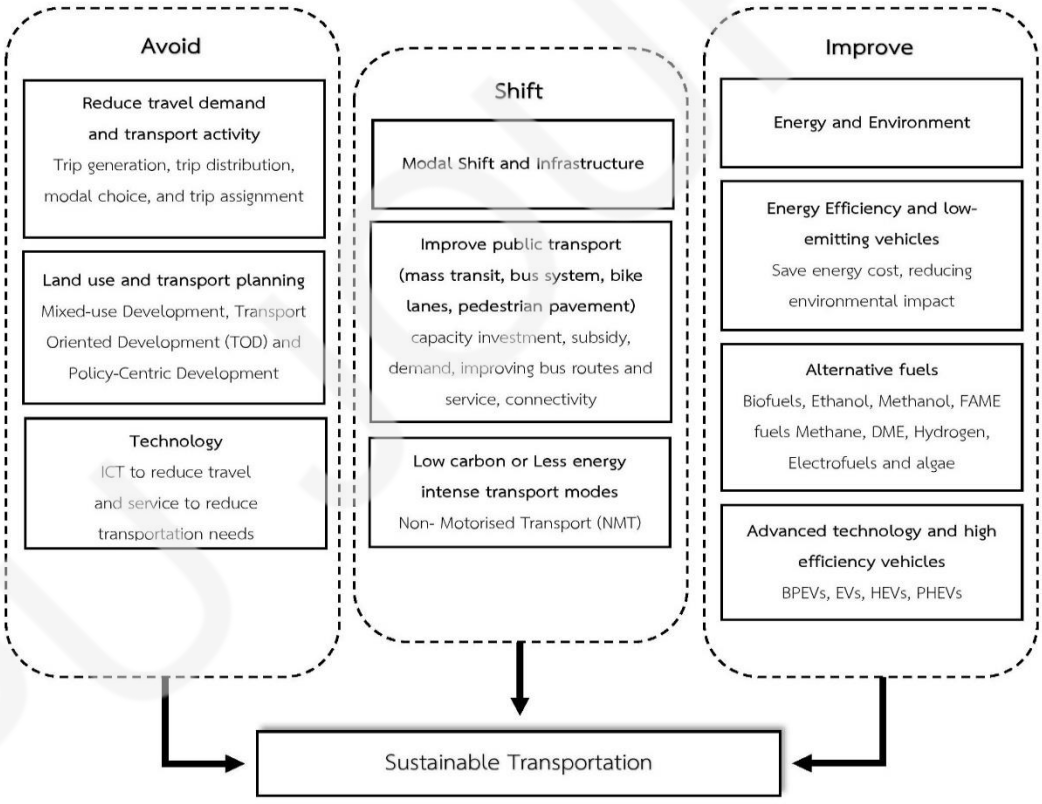

Figure 1.1 Conceptual Framework
Adapted from (Dhar, 2016 ; Farzaneh, 2019 ; Sustainable Urban Transport Project, 2011 ; Wismans, Grahn and Denbratt, 2016)

Research Methodology

This research used a qualitative approach. Data was collected through in-depth interviews involving key informants. Semi- structured questions are were as a tool to collect data.

Population and Samples

A total of 15 key informants were purposively selected from three different sectors; (1) eight key informants from public sector, (2) three key informants from private sector, and (3) four key informants from academic sector. The Key informants were selected for their intimate knowledge of the subject on which they will be interviewed, and their expertise based on their special social positions, experience, and professional expertise. The selection of key informants was based on criteria such as extensive experience in sustainable transportation, low carbon transportation policy, urban development, urban design, transportation planning, transportation engineering, civil engineering, energy master planning and/or environmental studies.

Research Instruments

A list of interview questions was used as a research instrument to collect data during in-depth interviews. Three set of questions were developed for three groups of key informants. Examples of questions included; “how does Bangkok have integrated ‘urban planning’ and ‘transport planning?”; “how does Bangkok proceed in the development of transport links in the inner city with road networks, waterway networks, and rail networks?”; “how might Bangkok modify public infrastructure to promote mass transit and shift to a reduction in the use of private cars?”; “what are the barriers or difficulties in achieving a sustainable transport system?”

Data Collection

The researcher used qualitative research technique for collect the information from the key informants. The research had studied the information from books, research documents, theses, academic articles, journals, electronic medias including other printing medias that have the content and related issues.

For the interview procedures, the researcher proceeded to interview which had the instrument-In-depth interview and list of question by preparing the letter to request the permission to collect the information from Faculty of Social Science and Humanities, Mahidol University and the document explaining to research participants in answering the In-depth Interview including the letter showing the intention to be consenting to join in the research for explaining the research detail and requesting for the assistance in giving the information which has procedures in data collecting. The in-depth interviews, after informed consent, were carried out during March 2019-December 2019.

Data Analysis

Interview data were transcribed and encoded to maintain the privacy of the interviewees. Data were analysed by examining the transcribed data and coding the information based on the scheme. For example, How Bangkok develop toward sustainable transportation, how can Bangkok integrate transport policy planning with Avoid-Shift-Improve Approach, what are the barrier or difficulties in achieving a sustainable transport system. From the considerable amounts of information were used the ‘Avoid-Shift-Improve’ (ASI) approach to analyse the 12-year development plan for Bangkok Metropolis (2009–2020). The empirical findings of this research were analysed by using pre-set criteria from the theoretical framework outlined above and via the findings of previous pertinent literature.

This study has been approved by the committee for research ethics (Social Sciences), Faculty of Social Sciences and Humanities, Mahidol University, Thailand (certificate of approval No. 2019/046.0503).

Result and Discussion

This section uses the ASI approach to evaluate the policies and strategies related to sustainable transportation in the 12-year development plan for Bangkok (Dhar, 2016; Farzaneh, 2019; Sustainable Urban Transport Project, 2011). The ASI approach is based on three principles: (1) avoid increased transport activity and reduce travel demands, (2) shift travel modes, and (3) improve existing forms of transport. To improve the sustainability of transport systems, the ASI approach calls for state policies to limit GHG emissions in the transport sector via a combination of measures which shift away from moving goods and people to ensuring access to goods and services. In this section, we first provide the evaluation criteria, followed by our recommendations. Our results showed that the ASI approach provides a worthwhile alternative to the 'predict-provide-manage' approach, which had previously been used in the transport sector in Bangkok (Farzaneh, 2019; OECD, 2017).

(1) Avoid Increased Transport Activity and Reduce Travel Demands

The Bangkok Metropolitan Administration (BMA) introduced land-use planning and utilised information and communication technologies to avoid the increase of transport activities and reduce travel demands as followings: (1) land-use planning, (2) transit-oriented development (TOD), and (3) information and communication technologies in transport systems.

According to the interviews, the BMA has developed strategies and plans in response to the emerging global situation and the transformation of Bangkok into a centre of national development and urban expansion. Urban planning development in Bangkok is complex and led to the physical unsuitability, which affected public infrastructure utilities and social services that people need. The BMA focused on comprehensive land-use planning as a guideline to facilitate mass-transit and communication-technology development. As a result of the Administration's decentralisation policy, many residents of Bangkok have relocated to the suburbs and the urban density in the inner Bangkok area has decreased. Sub-central business districts have been developed in the suburbs to subsidize the jobs-housing balance and guide future land-use and public-transport developments (Public Sector#2, Private Sector#3, Academic Sector#1). This study of the 12-Year Development Plan (2009 – 2020) found similarities between it and the Bangkok Comprehensive Plans produced since 1992 that were initiated as a guideline for developing Bangkok city. Later, the government established the Bangkok Comprehensive Plans of 2006 (B.E.2549) and 2013 (B.E.2556) to improve land-use zoning, transport activities management, and disaster prevention. In addition, the urban area in Bangkok expanded and intensified along to mass transportation routes. This decreased agricultural zones in the suburban areas as residential zones and commercial zones increased in their stead. For example, the land-use zoning plan shows an increase of urban residential zones from 300.89 km^2 (1992) to 481.54 km^2 (2013) and urban areas increased from 64.30 km^2 (1992) to 160.37 km^2 (2013). As well, the agricultural zones decreased from 674.29 km^2 (in 1992) and 617.41 km^2 (in 2013) to 192.97 km^2 (in 2015) due to residential area expansion (Department of City Planning and Urban Development, 2006, 2013 ; Office of Agricultural Economics, 2002, 2015 ; Posuk, Kajita and Petchsasithon, 2018).

> "*Comprehensive land use planning and 12-year Bangkok development plan tried to reduce the urban density and balancing jobs and housing area along with currently developing effectively mass rapid system projects to reduce travel demand*." Public Sector#2, 12th June 2019

"Bangkok probability to decentralise to a suburban, and to reduce the high-density area in inner Bangkok. Established the Central Business District – CBD to connect the old residential area with the mass transit systems."

Academic Sector#1, 16th August 2019

Furthermore, the interviewees from the public sector said that Bangkok is confronting urban-sprawl problems associated with commercial and residential land development due to mass-transit-system and public-infrastructure projects (Public Sector #3 #4). The jobs-housing development has been developed along with the mass transit system projects. Thus, the city's plans have been revised for mass transit infrastructure. The problems related to transit-oriented development in Bangkok resulted from the land use, public transportation development, and the inefficiency of the mixed-use development. The networks around the transit station are not suitable for passengers because the station exceeds walking distance (400-500 metres) and takes more than 2 minutes to walk (Academic Sector #2 #4).

"*The problems of Transit-Oriented Development in Bangkok are not suitable for developing to the residential and commercial area. As the concept of Transit-Oriented Development, a walking distance should walk not more than 20 minutes, and it should have a transit station to any destination.*"

Academic Sector#2, 25th August 2019

The key informants from the public, private, and academic sectors mutually agreed that Bangkok has enhanced the strategic administration plan for good governance and organisation development, based on data, information, and technology aiming to maximise efficiency in administration productivity. An information and communications technology system (ICT) has been incorporated as a tool to support the administration and operations in providing public services, complying with Bangkok's 'sustainable metropolis' vision, and encouraging Bangkok's administration and service providers to implement a balanced scorecard (Public Sector#2 #3 #5, Private Sector #3, Academic Sector#3).

"*Since e-government has been promoted for data collections, the priority for digital government should be the internal system development of computer and internet of organisations, including devices upgrading to networking communication*."

Public Sector#2, 12th June 2019

In practice, avoiding inefficient or unnecessary travel demand for Bangkok's transportation does not comply with the above principals because BMA have decentralised jobs and pushed the population into the suburbs rather than designing urban planning to accommodate the high-density urban area, causing increased travel activities. Besides the lack of integration of land use, transport planning creates barriers in the jobs-housing balance and TOD, which increase the distance between people's homes and their jobs in the central business district. This study aligns a with previous study found that the improvement of transportation linkages between the central business district and sub-centre can reduce dependency on the urban core and help workers reduce long-distance commutes (Loo and du Verle, 2017). According to Yang and Pojani (2017), one obstacle to achieving TOD is that the urban area is not high density enough for urban expansion management. Consequently, the TOD and land-use mix at activity central business district are difficult to implement. Thus, the density of the area needs to be monitored in the future.

The BMA has considered the importance of ICTs on transport systems. However, ICTs have been implemented for department users only, and there has been no ICT use in the transportation sector. Thus, it can be concluded that ICTs were not fully implemented in the transportation systems in Bangkok. This finding is contrasted with Gössling (2018), who found that ICTs are changing transport system methods and

increasing the need for sustainable transport. The government funded ICTs for transport demand, urban and rural transport planning and design, transport flow, and climate change.

Our recommendation to fill the gap between theory and practice is to increase the development of high-density housing near the transport nodes. Moreover, the government should invest in big data analytics and integrate transport information services by providing people with information about, transport mode costs and incorporating methods of making payments.

(2) Shifting Travel Modes

According to the Bangkok Mass Rapid Transit Master Plan (M-Map1 and 2), the BMA has developed a diverse number of public transport systems, focusing on the linkage of public transport between core systems (mass rapid transport) and feeder systems to achieve sufficient travel linkage capability (Public Sector #4 #5 #7 #8, Private Sector #2). For example, the BMA provided transportation (road, mass transit, and boat service) as a feeder system which included bus, bus rapid transit (BRT), express boat - in Chao Phraya River -- and light rail transit (LRT) (Public Sector#4 #8).

The government has made efforts to invest in the construction of massive rail systems to support the expansion of urban populations into the suburbs. They are developing the feeder system to support the city's expansion which registers passengers to the core system in inner Bangkok (Public Sector #5, Private Sector#2). Despite, the development mass rapid transport is an accomplishment for a long-running construction operation that makes travel with current mass rapid transport system still not enough routes demanding and uncover job and housing area. Despite, the increasing number of demand metro routes are enabled to underway to linkage and covering all area. A variety of other transport systems need to be developed to facilitate connection with the rail system (Academic Sector#1 #3 #4).

Although the BMA has attempted to increase mass transit system routes, these routes are not interconnected. The passengers have to travel using multiple costly transportation systems. Therefore, the mass transit system in Bangkok is unable to shift passengers away from using private cars toward using public transportation (Academic Sector#1 #3 #4). According to government statistical information about new registrations of private cars in Bangkok, the number of private cars increased slightly from 286,590 units (in 2011) to 305,230 units (in 2014), to 331,100 units (in 2017) and then to 374,300 units (in 2019) (see Groups of Transportation Statistics, 2020). This trend is set to continue in the future.

"*Since 1999, the master plan of mass transit systems was created and implemented for the mass transit system in Bangkok. For example, the URMAP, BMT and M-Map design to focus on the rail system, not for the road system as appeared in the previous master plan*."
Public Sector#7, 10th July 2019

"*In 2004, BMT approved the mass transit system projects from the first seven lines and in 2006 increase to 10 lines. The government revised the M-Map1 and M-Map2 to validated development of rail systems which integrated for land-use.*"
Private Sector#2, 1st November 2019

"There is One Transportation (road, mass transit and boat service) but these three are not connected."
Public Sector#4, 26th June 2019

"*There is an increasing number of mass transit system lines – now totally five lines but insufficient and not covered for demanding. In Bangkok, each train line constructs along the main road which overlaps with bus lines. Moreover, the mass transit system routes are not connected with the residential area,*

causing people will not use public transportation but use more private cars which lower cost than travel with the mass rapid system."

Academic Sector#4, 26th August 2019

This study supports the findings of Prasertsubpakij and Nitivattananon (2013), who found that mass rapid transport stations in Bangkok were poorly connected, uncomfortable, and costly, and that feeder services connection with metro lines need more integrated with other mass transit system. It is likely associated with the transport behaviour that passengers are avoid using public transportation and change behaviour to drive private vehicle alternative. In addition, people will not have an economic incentive to take public transportation since the mass rapid transport fee is much more expensive than using a private car, unless fare prices are reduced and free transfer options are introduced (Satiennam, Jaensirisak, Satiennam and Detdamrong, 2016 ; Sirikijpanichkul et al., 2017 ; Wu and Pojani, 2016).

To fill the gap between theory and practice, the government ought to develop bus, bus rapid transit (BRT) services, and other feeder systems which are flexible and require less construction time, maintenance, and operating costs. For example, bus and BRT services need to improve in terms of routes, safety, and punctuality of service. In addition, extension nodes and connections to the mass rapid system should be created to connect the central business district (CBC) and sub-centre. In order to persuade city dwellers to use public transportation rather than private cars, fare prices hsould be reduced, new safety measures should be implemented, and information about travel times and routes should be offered. A single ticketing system to access all modes of mass transit in Bangkok should be set up to facilitate passengers' ease of travel. Consequently, non-motorised transport is also needed to improve pedestrian safety and mobility for pedestrians, and to provide access for all types of pedestrian travel.

(3) Improve Existing Forms of Transport

Improving existing forms of transport means improving energy efficiency, alternative fuels, and advanced vehicle technology. All key informants mutually agreed that the use of combustion engines has been reduced by encouraging people to use alternative fuel sources such as gasohol. Supporting private and public transportation vehicles to use alternative energy vehicles and energy-saving technology can reduce greenhouse gas emissions (Public Sector#2 #3 #4 #8, Private Sector#3, Academic Sector#1 #4). The government has promoted electric vehicles through a taxation system which provides incentives in the form of low import tariffs for importers and tax exemptions to attract car manufacturers. However, the high price of electric vehicles was still unattractive to the buyers and could not convince them to buy them (Public Sector#3, Private Sector#3, Academic Sector #3). The finding of this study aligns with the statistical information regarding new registrations of individual electric cars in Bangkok which shows that there were 257 new units in 2018, 937 new units in 2019, and 1,821 new units in 2020. Therefore, the total EVs more than double in the past three years. However, a comparison of new registration of EV's with the new registration of Internal combustion engine shows that EV vehicles are significantly outnumbered. New EV's were just 0.02% of the total newly registered cars in 2018, 0.09% if newly registered cars in 2019, and 0.21% of newly registered cars in 2020.

"*According to the action plan, one of the principal approaches is to reduce the use of private cars for other transportation methods, encourage people for alternatives vehicles, and promote gasohol to lower greenhouse gas emission.*"

Public Sector#2, 12th June 2019

"*There is still no serious supporting measures from the government which gain more attention from the people. On the other hand, the government more emphasises on the manufacture's privileges such as tax reductions for parts and the company's annual tax for continuing and better development. In contrast, less than 2% of tax reduction for imported cars resulting costly still has been implemented for the consumers*."

Private Sector#3, 20th November 2019

This study found that the 12-year development plan for Bangkok partially complied with the 'improve' concept. The promotion of biofuel for alternative energy can reduce GHG emissions and conventional air pollutants. Fossil fuels have been replaced and the equivalent energy requirements have been reduced (Granjo, Nunes, Duarte, & Oliveira, 2020; Ng, 2019). However, in practice the fiscal incentive has not been successful because users were not convinced to switch to electric vehicles, which would generate lower carbon emissions and have a lower environmental impact. This finding contrasts with Haugneland, Bu, and Hauge (2016), who found that taxes incentives in Norway encourage consumers to buy electric vehicles. These incentives are successful in the electric vehicle market because the competitive price is attractive to buyers. Another study in Sweden confirmed that increasing fuel taxes and new vehicle taxation can increase electric vehicle use. Consequently, the CO_2 emission in transportation sector has been decreased (Pyddoke, Swärdh, Algers, Habibi and Zadeh, 2019).

To fill the gap between the theory and practice with regard to convincing users to switch to a hybrid vehicle or alternative electric vehicle, the government had to support the tax cut policy for electric vehicles that make them cost-competitive to attract buyers. In addition, the government should increase fossil fuel tax, to convince consumers to buy non-fossil fuel cars. Lastly, the electric vehicle's infrastructure such as sufficient public recharging stations should be provided around the city or nearby the mass transit stations.

Conclusion

Based on this study, it revealed that the content in 12-year development plan for Bangkok Metropolis (2009-2020) toward sustainable transportation goals partially applies ASI approach in transportation systems management. The evaluation showed that with regard to:

1. Avoid increased transport activity and reducing travel demand: Decentralisation, jobs-housing planning, and TOD were not integrated. The existing technologies were not used to manage transportation. Thus, this activity and travel demand were ineffective.

2. Shift travel modes: The BMA has developed various public transport systems, but the supply and demand of transport services were imbalanced. The ticket prices were too high, and the distance between nodes was disconnected. Thus, the shift to public transportation was unsuccessful.

3. Improve existing forms of transport: The BMA has promoted electric vehicles, but the tax-cut policies did not attract buyers. Thus, the task of improving existing forms of transport was ineffective.

Contribution

This study has contributed to the theoretical approach since it has confirmed that the 'Avoid-Shift-Improve' (ASI) framework is useful to analyse urban development plans and to provide alternative mobility solutions for urban sustainable transport systems in Thailand.

Suggestions

Based on the above evaluation, we arrive at a series of suggestions we propose in order that sustainable transportation in the city can be encouraged and allowed to prosper and proliferate. These are

listed below. (To achieve these sustainable transportation goals, local administrations such as the BMA and the National government need to develop collaboration between their agencies and organisations to ensure strong possibilities of mutual success).

1. The BMA should place importance on polycentric urban development and use the polycentric cities concept to promote spatial equity and balance regarding the role of transport (and to proceed to do this starting from use existing infrastructure).

2. The Department of City Planning and Urban Development, BMA should promote and support TOD around transit stations to foster potential urban investment activities (which may include enhancements to transit stations, pedestrian infrastructure, bicycle facilities and also integrating urban sites with mixed-use development – that is mixed residential and commercial development).

3. The Traffic and Transportation Department of the BMA should appraise proposals for new roads and other policies aimed at reducing congestion in Bangkok (such as road pricing system to manage demand of travel, shifts to other travel modes -- including public transport and pedestrianization -- and the raising of user-pays revenue for reinvesting in roads and public transport.

4. The Traffic and Transportation Department of the BMA and the Common Ticketing Office of the Ministry of Transport should launch a common ticketing system designed to link all modes of public transport in Bangkok. In consequences to improve system convenience and help reduce transit costs.

5. The Transport and Traffic Policy and Planning, and Department of Land Transport, Ministry of Transport, Ministry of Energy, and Ministry of Interior should promote electric vehicles, and excise tax-cut policy to attract buyer shift from internal combustion engine to electric vehicles.

6. The Bangkok Mass Transit Authority of the BMA should replace diesel and NGV buses with electric buses. This is beneficial since improving local air quality will greatly protect the environment and citizen health.

7. The BMA and the Electricity Generating Authority of Thailand, plus private investors, should propose significant investments to support non-fossil fuel car use, most especially a network of charging stations.

Our suggestion for future research is to study sustainable transportation in other cities in order to represent all urban areas in Thailand.

Limitation

There are some limitations to this study. Firstly, due to budget constraints, the researcher could only randomly select Bangkok as the study site, therefore the results may not be nationally representative. Secondly, the evaluation was dependent on either positive or negative experiences of key-informants which may introduce biases towards certain issues or organisations.

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