

# A Synthesis of Sustainable Public Transportation Logistics Model

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## Abstract

The purpose of this research was to synthesize the sustainable public transportation logistics model. The researchers reviewed the related literature in the 5 years prior to the COVID-19 pandemic. The research process began with searching, reviewing, analyzing, synthesizing and summarizing the data. The results showed that the key components of the sustainable public transportation logistics model consisted of 3 components:

1. Corporate of Governance: it included 1) Urban Form which were (1) Physical Form and Land Use, (2) Land Area and Density, (3) Centralities and Regionalism; and 2) Transport Policy which were (1) Regional Integration, (2) Funding and Finances.
2. Logistics Management: it included 1) Physical Flow which were (1) The Speed of Transportation, (2) The Economies of Transportation, (3) The Safety of Transportation, (4) Quantity of Vehicles in Transportation, (5) The Convenience of Transportation, (6) The Certainty and Timeliness in Transportation; 2) Information Flow which were (1) Internal Communication, (2) External Communication; and 3) Financial Flow which were (1) Determine the Appropriate Fare, (2) Smart Card, (3) Common Ticketing System.
3. Sustainable Public Transportation: it included 1) Economic Dimension which were (1) Funding, (2) Demand Management; 2) Social Dimension which were (1) Differences in Spatial Distribution, (2) Travel Expenses, (3) Health, (4) Public Safety; and 3) Environmental Dimension which were (1) Greenhouse Gas Emission, (2) Fossil Fuel, (3) Renewable Energy.

**Keywords:** A Synthesis of Model, Public Transportation, Logistics, Sustainable

## Introduction

Transportation and logistics are the important components of the country's economic development and improve people's life quality. At present, most users in Thailand prefer to use road transportation; the main reason is its convenience, fastness, and ability to deliver door-to-door despite the high transportation costs. Another reason is that other modes of transportation, such as railroad, waterway, and air, are unable to meet the demand in the aspects of availability of infrastructure and accessibility to the services. This is an obstacle to develop the efficiency of the country's transportation and logistics system.

Regarding the development of transportation infrastructure in Thailand, in addition to being important to the development of city, it is also a key factor in enhancing the country's competitiveness. The World Economic Forum (WEF) has ranked the competitiveness of each country in overall and in each individual indicator of its development with the infrastructure and logistics as one of its indicators. In 2019, Thailand was in 40<sup>th</sup> ranking from all 141 countries, which decreased from the year 2018 that Thailand had been in 38<sup>th</sup> ranking. For the rank of infrastructure quality, Thailand was in 71<sup>st</sup> ranking, decreased from 60<sup>th</sup> in 2018 (World Economic Forum, 2019). This might be due to the qualitative and quantitative problems on Thailand's infrastructure, and a lack of service management that is relevant to the international standard. In addition, regarding the survey on economic growth of 155 countries worldwide which operate the transportation and logistics work, it was found that the logistics development in Thailand is still at an unadvanced level. The Logistics Performance Index (LPI) of the year 2018 showed that Thailand was in 32<sup>nd</sup> ranking which was lower than other countries in South-East Asia, such as Singapore and Malaysia (World Bank, 2018). These problems are also the major obstacles to the development of the country's transportation and logistics system.

In 13<sup>th</sup> National Economic and Social Development Plan of Thailand, it indicated the direction to drive the development of the country's infrastructure by focusing on solving the structural problems to aim for a society of opportunity and fairness by spreading development to cities and economic areas. This is to spread the advantages from the economic prosperity out of Bangkok to other regions throughout the country. The private sector will have more opportunity to take a role as service provider, which will help support the full and efficient utilization of transportation investment projects. Therefore, people can access the infrastructure and quality public service. Other goals are to achieve the Thailand's Carbon Neutrality within 2050, to promote the environmentally friendly travel and the public transportation travel, to develop a low-carbon, environmentally friendly public transportation network covering the whole country, and to promote the production and use of clean and energy-efficient vehicles (Office of the National Economics and Social Development Council, 2022).

From the problems and directions for the development of transportation and logistics systems as mentioned above, they are an important issue that the researchers were interested in; therefore, studied "A Synthesis of Sustainable Public Transportation Logistics Model". Due to the above reasons affecting the transportation system that supports both freight and passenger transportation or public transportation, especially the efficient public transportation that is related to the city planning. The transport policy establishment, especially the public transportation, must consider the convenience of travel connections, the use of vehicles that are suitable for economic and social conditions, as well as environmental pollution; thus, creating the sustainable public transportation.

## **Purposes of Research**

To synthesize the sustainable public transportation logistics model.

## **Literature Review**

### **1) Logistics Management**

Logistics is essential for the development of the country's competitiveness and economy. Logistics is an activity about materials flow, information flow, and financial flow from the source to the end consumers at the right time and place with the right conditions, quantity and cost. It consists of the customer needs forecasting, the procurement, the packaging, the production and warehouse, the inventory management, the shipping and transportation, the customer service and the reverse logistics. The logistic management is the process of planning, executing, controlling the work of organization, including the management of related information and financial transactions to cause the movement, the collection and the distribution of products, raw materials, assembly parts, and to provide the most efficient service.

Many researchers were interested in this issue. Regarding the research result of Amaral & Aghezzaf (2015), the logistics of city involved transporting goods in the city. This included the transportation, the product management and storage, the inventory management, and all related receiving and delivering. The traffic management and control involved all operations related to traffic flow and infrastructure design, including the possibility to change the regular traffic lanes to reserved bus lanes, or to designate special lanes for freight transportation. It was a form of the most effective management strategies for city transportation and urban traffic management. Moreover, Kauf (2016) presented the fundamental development trends in the urban logistics area. Some concepts of sustainable transportation and the innovative technologies required for its operations, especially the intelligent technology to control the intelligent traffic. This helps reduce the burden on road infrastructure; thereby, improving the quality of the environment and city life. The main trend in sustainable urban transportation was the cooperation between suppliers, customers and government administration. To implementing the smart logistics required the development of new business models to benefit not only the city but also the operating units. In this regard, Rai, Verlinde, Merckx, & Macharis (2017) presented about the sharing of space for passenger and freight transportation. A sustainable logistics model improves the efficiency for customers and overall profits, optimizes the vehicle use and fosters the progress in social equity by creating the flexible jobs and encouraging the efficient use of transportation resources by cooperating with relevant stakeholders, such as consumers, businesses and policy makers. Speranza (2018) studied about transportation and logistics trends, and found that the freight problem related to public transportation and the design of infrastructure for the movement of private vehicles. Most vehicles were buses and trains which needed to be coordinated in terms of routes, schedules, and transit times, to optimize the transportation and logistics systems. Sullet, & Dossou (2018) found that to improve the urban logistics enabled the mobility, contributed to the sustainable growth and development to reduce congestion in road transportation,

reduced CO<sub>2</sub> emissions, improved people's life quality, protected the environment, and increased the efficiency of urban transportation and mobility (railway, waterway and bicycle, etc.). They also proposed the collaborative solution to reduce road transportation and congestion and to improve the urban logistics by using the alternative solutions (a combination of road, waterway and railway) in the region. Furthermore, the research of Dong, Xu, Hwang, Ren & Chen (2019) showed that the underground logistics system promoted an integrated urban transportation system, was able to significantly improve city traffic and transportation, especially increased the average speed of the road network during rush hours, reduced the time wasted on rush hour travel, and reduced PM emissions of trucks. This contributed to the sustainable development in the city. From the above literature, it shows that the logistics management plays an important role in the development of sustainable transportation system.

## **2) Public Transportation**

Public transportation or mass transit is a form of land transportation that mainly focuses on transporting passengers. The related authorities as owner and management come from both public and private sector. The main objective is to provide service to community. The important transportation modes of Thailand are 1) railway transportation, 2) public transportation system in the city, 3) road transportation, 4) air transportation, and 5) waterway transportation (Office of the National Economics and Social Development Council, 2017). The development of the transportation system involves these issues: 1) green and safe transportation which were (1) promoting the safe transportation in all modes of transportation, (2) promoting the environmentally friendly transportation; 2) transport efficiency which were (1) optimizing transportation and logistics, (2) using the Intelligent Transport Systems (ITS) and technology to upgrade transportation services and manage transportation systems for maximum efficiency, (3) inclusive transportation (Office of Transport and Traffic Policy and Planning, 2016).

The sustainable public transportation is an interesting issue for many researchers. De Gruyter, Currie, & Rose (2016) found that previously, the sustainability of public transportation systems in developing countries was limited. For the developed countries in the Western, there are better sustainability measures in terms of environmental and social indicators which show that the developed countries pay attention to the sustainability measures of public transportation. Accordingly, Miller, de Barros, Kattan, & Wirasinghe (2016a) found that public transportation was an important framework for building sustainable cities. On the other hand, the social, economic and environmental impact of transportation was a key issue that can challenge the sustainability of cities and regions, which is a recommendation for engineering planning and research on sustainable public transportation. Miller, de Barros, Kattan, & Wirasinghe (2016b) also found that in recent years, the role of public transportation systems has been identified as a key component in promoting sustainable cities that can be used for planning, decision-making and studying in research contexts. Wu, Ma, Long, Zhou, & Zhang (2016) proposed the development of public transportation systems and highlighted buses as a possible solution for improving the level of public transportation services; thereby, solving the congestion and helping in the urban development and urban sustainability. They also introduced a new bus control strategy, including the ownership control and the speed control, in order to improve the service level of the transportation system within a connected vehicle environment. Moreover, the research result of Stawiarska, & Sobczak (2018) shows that the components of the transportation network (road system density, rail system density, number of regional rail and bus connections, length of regional rail and bus connections for the development of IT techniques for the benefit of public transportation systems) was essential for the development of public transportation systems. Gatta, Marcucci, Nigro, Patella & Serafini (2019) also stated that the public transportation model that assessed environmental and economic impacts provided local policy makers and transportation companies a good database for the development of public transportation models and to assess the potential impact of the system from an economic and environmental perspective. From the above literature, it shows that sustainable public transportation plays an important role in the overall development of transportation and logistics.

## **3) Sustainable Transportation**

The sustainable transportation system is very important because it has a direct impact on human health and safety. The urban transportation system is a complex system involving both the transportation of goods and the travel of passengers. The sustainable transportation design is one of the most pressing issues that modern cities have to encounter in the midst of economic growth and social equity without increasing the concentration of pollution in the atmosphere and degrading the natural environment.

Many researchers were interested in the sustainable transportation system. The research results of Maheshwari, Kachroo, Paz, & Khaddar (2015) show that the sustainable transportation system planning required a holistic approach for integration. It should consider the transportation of economic activities, environmental and social impacts simultaneously. It should also establish the policies related to stakeholders in transportation activities and environmental systems. On the policy side, the investment in energy-saving technology and its impact on the state should be considered by discussing to help make investment decisions.

It should use the most appropriate control techniques in the designing. In the long run, the public sector or decision makers should adopt the systems and control methods to develop the most appropriate policies to achieve their desired goals. In addition, Pojani, & Stead (2015) found that factors affecting the sustainable urban transportation in the developing countries are: 1) road infrastructure, 2) railway public transportation system, 3) road public transportation system, 4) the supported system for non-motorized modes of transportation, 5) technology solutions, 6) campaigns to create awareness, 7) pricing mechanisms, 8) vehicle access restrictions, and 9) land use controls. Accordingly, Holguín-Veras, Sánchez-Díaz, & Browne (2016) found that the sustainable urban freight forwarding and freight demand management was a new paradigm of urban transportation that improved the economy in terms of productivity and efficiency, and increased the environmental sustainability, life quality, and environmental justice. Moreover, Shen, Du, Yang, Du, Wang, & Hao (2018) found that the transportation development strategies in terms of the economic and social, the demand-side and supply-side was helpful in reducing decision-making errors and achieving the goals of sustainable urban development, especially in the emerging cities. From the above literature, it shows that the sustainable transportation system should focus on the development of economic, social and environmental transportation at the same time.

## **Research Methodology**

The researchers reviewed the relevant literature and synthesized the research relevant to a new paradigm for sustainable public transportation in the 5 years prior to the COVID-19 epidemic. The research process began with searching and reviewing the research articles and thesis retrieved from the electronic database; then analyzing, synthesizing and summarizing each academic document in order to indicate the components for sustainable public transportation and to propose a conceptual framework for the sustainable public transportation logistics model.

## **Research Results**

From the synthesis of relevant literature, they have been used to indicate a conceptual framework for the sustainable public transportation logistics model with the following components;

### **1. Corporate of Governance**

The Corporate of Governance consists of Urban Form and Transport Policy, as follows;

1) *Urban Form* which are Physical Form and Land Use, Land Area and Density, and Centralities and Regionalism.

(1) *Physical Form and Land Use*: the demand of residential land use and transportation systems that can be linked to other work center and other areas in urban area affect the horizontal urban sprawl to the suburban farming area of the housing estate, including the development of road networks and transportation. The problems in the management of the city's public transportation system led to the increasing number of private cars, the traffic congestion, the CO<sub>2</sub> emissions into the atmosphere causing the global warming, including the climate change. The city planning, in terms of land use and the city's transportation system in the future, is an alternative as a strategy for city planning, especially in the area related to land use, the creating of alternatives for travel with the concept of transportation system development aiming to preserve open space, the suburban farm land, the conservation area, including the historical areas of the city.

(2) *Land Area and Density*: the traffic density in large cities due to the reason that the country's transportation system still relies mainly on the road system which is a network that looks like a radius running into the center. The traffic volume increases as it gets closer to the center of the country's large communities. It can be seen that the growth of city has caused a large increase in the number of vehicles, especially private cars. It shows that a lack of a good and standard public transportation service system cause more severe traffic congestion in Bangkok. This problem will spread to other central communities as well. The effect of traffic

congestion in these metropolitan communities has caused the great loss to the economy system as a whole, both in terms of the waste of fuel, time and other invisible expenses.

(3) *Centralities and Regionalism*: the urban form will spread out from the center of the city (Centralities). The communities will be located along the route linked to the industrial zone and commercial zone. The communities also form at the zone of rest stop or the interchange point of transportation modes between the residential and work areas. The frequency of urban commuting has increased so that there are more specific areas of activity, such as commercial zone, industrial zone, and transportation zone. Therefore, the expansion of transportation network combines with personal cars lead to the increase of travel distance, the expansion of the scope of city, and eventually growing to be a metropolitan city. The expansion of the transportation system can reduce the burden of congestion to the city in 2 ways: 1) in short term, it helps the city center area to have the ability to increase accessibility as a distribution of land density and price to suburban areas; 2) in long term, it helps facilitate the travel to connect each area of the city. This helps reduce the density in the city area. Such phenomenon will help improve accessibility to all areas of the city; and the connection of activities within the city will be more appropriate, especially in areas where the transportation system is expanding.

2) *Transport Policy* which are Regional Integration, and Funding and Finances.

(1) *Regional Integration*: it is to connect the transportation routes within and outside the region. The development of infrastructure and transportation services of the country consists of providing the infrastructure, the transportation facilities, the within-city, intercity and international transportation to cover the entire region of the country, as well as connecting the international transportation to be efficient, convenient, fast, safe and standardized. The major change in society and world economy in the future will inevitably affect Thailand. The global society will be more closely connected as a borderless state. The effective policy making requires flexibility, innovation and creativity as well as the ability to adapt to rapid changes in the environment and the economic integration in the region. These lead to the connection of all systems.

(2) *Funding and Finances*: The Infrastructure Fund (IFF) is a mutual fund established to raise funds from general investors, both retail and institutional investors, in order to invest the money in the infrastructure projects that benefit the public at large. The joint investment approach between the public and private sectors (Public Private Partnership: PPP) has started to play an increasingly important role. It will help reduce the burden of the government's budget and public debt because some infrastructure investment projects are in large scale and require large capital investments. If the government invests and operates all by itself, the project may be difficult or delayed. Therefore, allowing the private sector to participate in investment will increase the efficiency of competition and enhance the quality of service that people receive. PPP may be in the form of a private company as a service provider to manage the system or to do the civil construction. The government and private companies will allocate benefits and risks together; both in the form of 'Net Cost' which the private sector has the right to collect income and allocate some returns to the government according to the agreement. The private sector will have to take the risk from all operating results. The 'Gross Cost' will be in the form of the government collecting all income and compensating the full operating cost for private companies in the form of the fixed payments.

## **2. Logistics Management**

The logistics management consists of Physical Flow, Information Flow, and Financial Flow, as follows;

1) *Physical Flow* which are The Speed of Transportation, The Economies of Transportation, The Safety of Transportation, Quantity of Vehicles in Transportation, The Convenience of Transportation, and The Certainty and Timeliness in Transportation.

(1) *The Speed of Transportation*: to provide rapid public transportation services, there must be an appropriate route survey, such as surveying the amount of service users, the duration of the bus in each route, etc., in order to plan the route to be suitable for the needs of service users. In addition, it also needs to be planned to solve the intersection problem by establishing a network of underpasses, elevated bridges and the expansion of shortcut routes. This helps speed up the travel both by private cars and public transportation.

(2) *The Economies of Transportation*: to economize the expense of transportation cost, the public transportation service providers must have good management in order to have the lowest cost but still able to provide good service quality. The low transportation cost also results in lower fare collection rates, and cost savings on fares. The expenses in this part are the expenses that the service user has to bear. Therefore, if the

lower fares are collected, the cost of living will be reduced; and if the public transportation service is efficient, it will affect the life quality of the users. Finally, it will attract more users to use it.

(3) *The Safety of Transportation*: the public transportation is a mode of transportation that has a large number of users. Therefore, the safety is an important issue in terms of regulating vehicle, driver and service standards. The speed of the car should be controlled to reduce accidents and controlling the safety of the user's property because a large number of users can cause theft problem in crowded areas. Therefore, increasing the amount of traffic volume to meet the demand for services may be a good solution to reduce such problems. In addition, this includes the accident free in the running of the vehicle, in the cabin, no fall of luggage to the passengers, preparing fire protection equipment, and the availability of first aid equipment in case of emergencies, etc.

(4) *Quantity of Vehicles in Transportation*: at present, the quantity of vehicles providing public transportation services is still insufficient to meet the demand of people, especially in Bangkok. Therefore, when the service is insufficient to meet the demand, there will be crowding in both land and waterway transportation which will affect the safety of service users. Accidents arising from using the public transportation have continued to occur and have resulted in both body and property damage. If increasing the quantity of vehicles providing public transportation services to meet the demand, it will provide users with more safety.

(5) *The Convenience of Transportation*: having the attentiveness in providing convenient services to passengers, taking into account the welfare of passengers, such as the cleanliness and hygiene of the seats, having officers to monitor public order and to receive complaints on vehicles, providing quality vehicle for servicing, available open route, users are facilitated when using the service, such as when and where tickets are sold, location of train station, location of bus stop, etc.

(6) *The Certainty and Timeliness in Transportation*: due to the uncertainty of the bus schedule, users of public transportation cannot determine the exact travel time. Therefore, they turn to use private cars more; as a result, the traffic jams. The development in this issue will allow people to estimate their travel time, including being able to spend less travel time and reaching the destination on time more. The bus schedule or the service providing should be appropriate; the passengers do not have to wait for the bus too long, or the bus comes too often and have no passengers. Moreover, it should consider the travel speed, the ability to keep time, and the punctuality.

2) *Information Flow* which are Internal Communication and External Communication.

(1) *Internal Communication*: the internal communication is to create understanding and good relationship with the people within the organization in order to create harmony and unity, to boost morale, and to build loyalty to the organization. If there is effective internal communication, the personnel will be able to acknowledge the policy, information, organizational movements or to have spaces for expressing ideas. It will eliminate problems that may be caused by misunderstandings. In addition, it enables to see the progress and feedback opinions of people in the organization, and to develop the organization to move forward correctly for the progress and good image of the organization.

(2) *External Communication*: the external communication is to create understanding and good relationship with people outside the organization, which are the general public, and the people that the organization is involved in, such as customers, consumers, as well as neighborhood communities, etc. This aims for these groups of people to have a better understanding of the organization and to cooperate with the organization as well. The external public relations must involve a large group or a large number of people; therefore, using the media to help disseminate news to the public, such as newspapers, radio broadcasting, television and online media, etc. Nowadays, the organizations prefer to use online media to help publicize, notify travel information through an online information system so that the passengers can view anytime and anywhere, along with creating a map showing the connecting travel routes clearly indicating the starting point and destination, the passengers can quickly understand. The signposts must be clear and easy to understand by using easy language and standard format, in suitable amount, and being systematically installed.

3) *Financial Flow* which are Determine the Appropriate Fare, Smart Card, and Common Ticketing System.

(1) *Determine the Appropriate Fare*: currently, public transportation service providers have to bear the burden of increasing costs and do not receive direct government subsidies. They need to control and manage costs greatly, this affects the service development, including new investments by public transportation operators. The important thing is that the fare rate setting should be fair to private operators as well as be fair to the passengers who use the service. The fare rate adjustment is an important matter that must be continually

considered with the appropriate adjustment mechanisms and the annual continuity. This includes a compensation plan for low-income people who are affected by government policies to create fairness in using services. Moreover, the service providers should be evaluated on service efficiency so that they can find good service operation guidelines and have enough funds to invest in developing bus service standards, which will encourage more people to use the services in the future.

(2) *Smart Card*: the smart card has been used to increase the efficiency of service delivery. It helps reduce the cost of distributing passenger cards, speed up the access, and increase convenience for passengers. That is, passengers do not need to take their cards out of their pockets to insert them into the card reader as they do today, but simply bringing the pocket with the card in it close to the card reader, passengers can pass in and out without wasting time. Regarding the use of smart card in the public transportation system, many countries have switched to use smart card more and more, such as Singapore. Every train and bus station in Singapore has replaced the existing passenger card with a smart card instead, in which passengers can walk through the metro door or get on a bus without stopping to insert the ticket into the card reader, just bring the smart card close to the card reader at a distance about 1–5 centimeters, they can go through the door.

(3) *Common Ticketing System*: in foreign countries in Europe and Asia, there has been a common ticketing system for a long time. This is a ticketing system that can be used for all modes of public transportation, such as public buses, electric trains, boats, including paying tolls or applying to non-transportation services, such as restaurants, convenience stores, or car parks. This system will provide people with convenience in connecting to travel when they want to change modes or routes without having to worry about wasting time in exchanging coins for tickets. Other major cities around the world also have a common ticketing system for the public transportation. London, England, has the Oyster Card. South Korea has the T Money Card. Hong Kong has the Octopus Card.

### **3. Sustainable Public Transportation**

The sustainable public transportation consists of Economic Dimension, Social Dimension, and Environmental Dimension, as follows;

1) *Economic Dimension* which are Funding and Demand Management.

(1) *Funding*: at present, the service providers have to bear the burden of increasing costs and do not receive direct government subsidies. They need to carefully control and manage costs; this causes an effect on the service development, including new investments. The important thing is that the fare rate setting should be fair to both service providers and passengers. Moreover, the service providers should evaluate its service efficiency so that they can establish the guidelines for providing good service and have enough funding to invest in developing bus service standard, which will attract more passengers to use the bus services in the future.

(2) *Demand Management*: there are many types of transportation systems that the government decides to invest in. The biggest challenge is that the project has to meet the demand of consumers around the clock. While the public transportation will help alleviate peak traffic on rush hour, the regulators still encounter the challenge of ensuring that the public transportation infrastructure is flexible enough to handle passenger traffic throughout the day. There are also challenges in pricing the fare rate to cover maintenance costs but reasonable for passengers.

2) *Social Dimension* which are Differences in Spatial Distribution, Travel Expenses, Health, and Public Safety.

(1) *Differences in Spatial Distribution*: although many people travel out of cities, in fact, people tend to choose to live in areas where employment opportunities and facilities are more likely to be located. As a result, people choose to use personal cars which may take a long travel time (causing traffic congestion and greenhouse gas emissions) or choose the public transportation which may not be fully integrated into a modern transportation network which will be convenient to access, and connect to various areas outside the central city. Thus, the differences in spatial distribution presents a significant challenge for governments trying to meet the travel demands of citizens in aspects of the socio-economic and population age disparities.

(2) *Travel Expenses*: the travel expenses are often a deterrent for people who tend to choose to travel by public transportation. Sometimes, it is found that traveling by private car is cheaper. In addition, the public transportation in various modes do not integrate into a unified system. As a result, traveling by public transportation takes more time than using a private car.

(3) *Health*: the human health is affected by pollution, especially the infants, the elderly and people with respiratory diseases. While the government has been successful in reducing air pollution from transportation and other sources, the behavior of traveling by private car for a long time may cause acute respiratory illness, stress from anxiety, and indirect effect on health, such as obesity and heart disease, etc.

(4) *Public Safety*: in the urban communities with a variety of transportation modes, citizens are often faced with the challenge of ensuring that road users are safe, comfortable and educated enough to use integrated public transportation systems. The first thing is that the pedestrian and bike lanes may not be prominently marked by dividing roads with car users, which contributes to the increase in death rates from accident. In addition, a lack of knowledge of each type of road survey has a significant impact on safety.

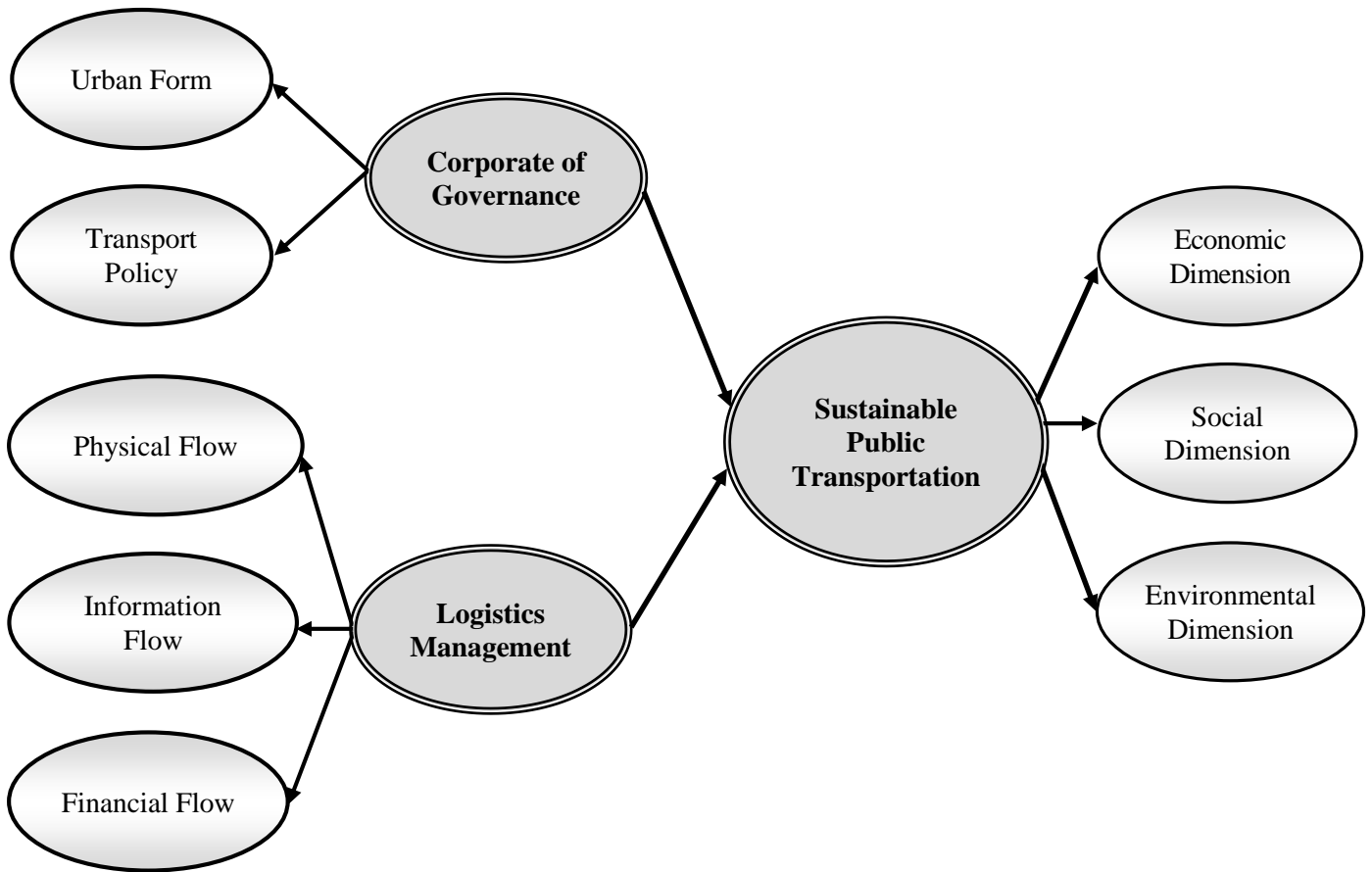
3) *Environmental Dimension* which are Greenhouse Gas Emission, Fossil Fuel, and Renewable Energy.

(1) *Greenhouse Gas Emission*: the public transportation systems play a part in greenhouse gas emissions, which are an air pollution problem in Bangkok and its vicinity. The current situation suggests that the major sources of such problems are traffic and transportation, construction and industrial plants. The key factor is the rapid increase of population because big cities are the center of prosperity and transportation; thereby, the way to prevent air pollution problems that will occur in the long term is to establish the appropriate legislative measures, to educate people about air pollution, and to do the city planning that must be aware of the negative effects of air pollution, such as dividing urban areas according to the nature of the activity because it can help reduce the dangers caused by air pollution as well as to control the actions in each specific area properly.

(2) *Fossil Fuel*: the wasteful fossil fuel, like coal, petroleum, and natural gas, is increasingly being used in transportation systems, causing the natural resources to rapidly deplete and affecting fuel price volatility. Thailand, as a high energy consumer and importer, especially in the transportation sector, consumes a lot of energy and causes a lot of pollution to the environment. The reduction of energy consumption and pollution from transportation sector is a challenge in Thailand, which is an agricultural country, with many raw materials that can be used as feedstocks. The government has a strategy to develop ethanol and biodiesel production to replace imported gasoline and diesel, which has the possibility of using ethanol and biodiesel for transportation in the next 5 years because of the sufficient amount of raw material production area as essential components of bioenergy production.

(3) *Renewable Energy*: the management to use environmentally friendly transportation technologies, such as the use of technology to save energy, reduce energy consumption, reduce pollution that affects the environment, and reduce the emissions of heat and greenhouse gas that affect global warming. Therefore, the green transportation causes changes in various modes of transportation technology by focusing on the use of environmentally friendly technology (Green Technology) and clean energy to develop the management of vehicle, modes of travelling or transportation of goods by land, waterway and air. In general, the green transportation will replace gasoline and diesel engines with less polluting renewable energy or clean energy, such as cars that use NGV, LPG, hydrogen gas, biodiesel, electricity and hybrid vehicles, or alternative energy vehicles are used more and more.





**Figure 1 shows the sustainable public transportation logistics model.**

### **Conclusion and Discussion**

Regarding the synthesis of sustainable public transportation logistics model, there are the interesting issues as follows;

1) The corporate of governance that affects sustainable public transportation logistics consists of 1) Urban Form which were (1) Physical Form and Land Use, (2) Land Area and Density, (3) Centralities and Regionalism; and 2) Transport Policy which were (1) Regional Integration, (2) Funding and Finances. This is in line with Thailand's 20-Year Transportation Development Strategy (2017-2036), the 20-Year National Strategy (2017-2036), and 13<sup>th</sup> National Economic and Social Development Plan of Thailand (2023-2027) in the fifth milestone indicating that 'Thailand is an important gateway for trade and investment, and logistics strategy of the region'; and the eighth milestone indicating that 'Thailand has smart areas and cities that are livable, safe, and grow sustainably'.

2) The logistics management that affects sustainable public transportation logistics consists of 1) Physical Flow which were (1) The Speed of Transportation, (2) The Economies of Transportation, (3) The Safety of Transportation, (4) Quantity of Vehicles in Transportation, (5) The Convenience of Transportation, (6) The Certainty and Timeliness in Transportation; 2) Information Flow which were (1) Internal Communication, (2) External Communication; and 3) Financial Flow which were (1) Determine the Appropriate Fare, (2) Smart Card, (3) Common Ticketing System. This is in line with supply chain management principles (SCM) which consists of the materials flow, information flow and accounting in financial flow. The concept of logistics management must be integrated to cover all aspects and to measure efficiency in all 3 parts which are the information flow, the physical flow of goods and services, and the financial flow. These 3 parts lead to the goals and bring about the efficiency and return of logistics development and respond to national economic and social development strategies (The Secretariat of The House of Representatives, 2015).

3) The sustainable public transportation consists of 1) Economic Dimension which were (1) Funding, (2) Demand Management; 2) Social Dimension which were (1) Differences in Spatial Distribution, (2) Travel Expenses, (3) Health, (4) Public Safety; and 3) Environmental Dimension which were

(1) Greenhouse Gas Emission, (2) Fossil Fuel, (3) Renewable Energy. This is in line with the concept of sustainable development which comprises 1) economic growth, 2) social equality to meet the demand of the present generation people, and 3) environmental protection to meet the demand at present and in the future. The concept of sustainability takes into account the related dimension of economy, society and environment. This is relevant to the Triple Bottom Line or Profit-People-Planet concept (Lertdetdecha, Chutikorntaweessin, Yodthong, Kamolrat, 2015) and also in accordance with the results of the study of Karjalainen, & Juhola (2019). They found that the transportation plays an important role in urban sustainability planning and greenhouse gas emissions reduction in cities worldwide. The sustainability agendas and policies has been established to guide the transition from transportation systems that rely on private cars to the use of public transportation, cycling and walking. While the urban form and regulatory structure of public transportation services also have other factors to consider when discussing about the sustainable development, such as the comprehensive planning and a locally independent policy assessment framework.

### **Recommendations**

1. Regarding the corporate of governance that affects the development of sustainable public transportation systems, the government should be aware of 1) urban form and land use, 2) land area and density, 3) centralities and regionalism, 4) regional integration, 5) funding and finances, and 6) long-term goals. The government must establish the urban development policies and the transportation policies to support socio-economic growth and population diversity, along with finding solutions to reduce environmental pollution problems and congestion in the city.
2. Regarding the logistics management that affects the development of sustainable public transportation systems, the government and the transportation service providers should improve 1) the speed of transportation, 2) the economies of transportation, 3) the safety of transportation, 4) quantity of vehicles in transportation, 5) the convenience of transportation, 6) the certainty and timeliness in transportation, 7) Internal Communication, 8) External Communication, 9) Determine the Appropriate Fare, 10) Smart Card, and 11) Common Ticketing System. However, the government and the public transportation service providers must plan and implement the plan together, and the public people must cooperate and support.
3. The public sector should formulate a strategy plan on the public transportation logistics to preserve the environment in the supply chain process, such as the development of public transportation systems that directly affects people's livelihoods and the environment, especially in terms of pollution that causes the life quality problems. The suitable guidelines to maintain the development balance is to develop sustainable public transportation with an emphasis on reducing the impact on society and environment, especially on reducing pollution caused by public transportation activities and on increasing the quality of life of the people.
4. The public sector should formulate a long-term strategy that integrates various systems both geography and travel modes. The sustainable transportation system can meet the basic demand of individual accessibility and mobility in a safe and affordable way. The public transportation should have various options and support good public health and economy by limiting the pollution emission and reducing the wasteful use of resources.
5. The public sector should promote environmentally friendly public transportation, develop the public transportation systems in major regional cities to be the alternatives for travel, especially waterway and rail transportation, develop the road transportation facilities to encourage people to reduce using private cars, such as bicycle parking spots, park-and-ride, convenient and safe pedestrian walkways, etc., and promote the switch to use the alternative energy and environmentally friendly transportation technologies, such as electric car.
6. The public sector should promote safe public transportation in all modes by focusing on providing a safe and standardized infrastructure, enforcing traffic and transportation laws, such as regulating the compliance of all public transportation operators and cultivating the traffic discipline, especially for the road users because of a high rate of road accidents. Moreover, the public sector should adopt modern technology to develop infrastructure and manage the transportation efficiently.

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