



Chapter 15

Public Transportation Transformation Towards a Smart, Efficient and Inclusive System

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A. Overview of Public Transportation Transformation

Transportation has been vital for human civilization from centuries BC until today. Transportation is a means to move goods or people's needs from one place to another for an objective (Adeniran & Olaniyi, 2016). Through transportation, the development of the economic sector is highly supported for the distribution of products. A transportation unit also significantly helps the accessibility of civilization movement to fulfill daily needs. The first significant revolution in transportation occurred in Europe from 1760 to 1850, affecting human life worldwide. Society previously utilized animals to assist the primary transportation need. When the industrial revolution came,

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they changed transportation to trains which used coal as the primary energy source. This displacement impacted human mobilization more efficiently and faster. Today, we must prepare to face the fifth industrial revolution as known society 5.0. Undoubtedly, it affects the growth of the applied science faster and more sophisticated increases.

Transportation has made various contributions to society living in urban and rural areas. Good transportation infrastructure can accelerate the productivity of the economic sector (Kutty et al., 2020). The existence of transportation can impact the development and sustainability of an area's economic, environmental, and social of the society. Through modern transportation, an industrial economy exceeds various territorial boundaries, even different continents. More significantly, transportation has a vital role in industrial activities for fast and efficient logistics distribution. The transportation component of the industrial sector consists of warehousing (distribution centers), trucking, trains, and specific supporting industries. Transportation plays an important role in running the economy in the community's welfare because there is a facility that can move people and goods from one area to another to obtain core needs and build the socio-economic capabilities of the community.

Moreover, the existence of transportation provides facilities as a mode of support for the community's daily life. The mobility of residents in their daily activities, especially to work, is highly dependent on public or private transportation facilities. For instance, BPS, The Central Bureau of Statistics (BPS) in Indonesia, states that train passengers in November 2021 experienced a 15.60% increase in commuters compared to October 2021 (Dihni, 2022). On the other hand, transportation infrastructure influences the environment directly and indirectly. The direct impacts are land taken for building infrastructure, visual disturbance, noise during construction, and infrastructure utilization. Then, the indirect impact is environmental pollution which is the biggest impact on climate change (Gudmundsson et al., 2016).

For government policy, a good transportation facility accelerates the goal of developing infrastructure in various areas. Building

facilities in rimland areas requires distributing labor and materials from other places. Indonesia's government objective to develop regions such as Papua first requires good transportation both for pathway and conveyance. Government services also need the service of transportation to be optimal in executing their program. Moreover, the transportation system also impacts social interaction, especially in Indonesia, which has a tradition of gathering and visiting each other. Therefore, infrastructure development is highly strategic to improve the welfare of a country.

However, to build a modern transportation system and infrastructure, procurement of infrastructure systems not only focuses on massive quantities but also pays attention to the system's sustainability. Sustainability in the transportation system must achieve a condition that the presenting needs are gained without compromising the ability of the next generations to attain their desires and concern for the natural resources, the prosperity of society, availability of future resources, and conforming the human values (Shiftan et al., 2003). To realize the sustainability of transportation systems, planning management requires integrating various components while considering a comprehensive procedure (Maheshwari et al., 2015).

One of the most critical transportation systems is the public transportation unit. Public transportation allows more people to travel along a defined route, such as buses, trains, and cars, and the period of services operates on a set schedule. The advances in technology and science contribute novel systems to public transportation through applying artificial intelligence and big data. Many countries have developed their public transportation to achieve a sustainable transportation system. In a developing country such as Indonesia, transportation public has lack in providing excellent services than private transport for society. The success of public transportation management indicates that the government's policies are working effectively. Moreover, currently we face a post-pandemic situation, so an analysis of the current needs and prospect needs to be done.

To realize society 5.0, we must comprehend this idea's pillars. One of its pillars is the public transportation system which significantly impacts society's goals and values. Public transport facilities lead to various impacts and advantages to society locally. It gives references for the policy to make decisions where transport sustainability corresponds to society's needs (Stjernborg & Mattisson, 2016). To realize a sustainable public transportation system, we initially analyze several issues related to public transportation in Indonesia as follows:

B. Traffic Congestion

As the fourth most populated country in the world, traffic congestion still becomes a problem faced by residents in Indonesia. According to data from TomTom in 2021, the capital city of Indonesia, Jakarta, got the traffic index of the top 10 in the world.

INRIX, a company engaged in the data analysis, states that Surabaya is the most congested city in 2021, achieving 62 hours as the amount of time wasted in a year due to traffic as seen in Table 15.1 (INRIX, n.d.). Then, the congested cities in Indonesia are followed by Jakarta, Denpasar, Malang, and Bogor, where the percentage decreases compared to the previous year. However, these cities still have high traffic jam, which have many impacts.

Table 15.1 The Top Five Most Congested Cities in Indonesia

Ranking	City	Global ranking (2020)	Global ranking (2021)	Hours lost during traffic jam*	Hour lost percentage pre-Covid
1	Surabaya	361	58	62	72%
2	Jakarta	55	409	28	-81%
3	Denpasar	142	359	31	-48%
4	Malang	46	394	29	-49
5	Bogor	1014	861	7	-224%

*During one year in 2021

Source: INRIX (n.d.)

One factor influencing the traffic congestion of big cities in Indonesia is a traffic system that still mixes up all types of transportation modes, both local and regional (Wijanarko & Ridio., 2019). Some big cities have regulated the mode of transportation in a pathway, but it is not applied extensively. The traffic congestion also cannot be separated from a large number of private vehicle users compared to the number of public transport users.

BPS record that the number of motorcycles owned by residents is 115 million units, while cars achieve a 21 million units (BPS, n.d.). Private transportation still becomes the first choice for residents. This paradigm must be changed while the government must provide good public transportation. The impact of traffic congestion not only affects the mobility of the society but also the cost of environmental prolusion. Especially during the period of leaving and returning from work, traffic jams occur in almost all big cities in Indonesia.

C. Inadequate Public Transportation

The large number of residents who have private vehicles shows that the role of public transportation is not yet utilized for community mobility. Based on BPS data, the number of users of motorbikes and private cars each year has increased in percentage compared to the previous years. We take Jakarta as the capital city as an example. The number of motorcycle users in 2020 is 20 million people, while the number of car owners reached 3 million, both of which have increased in percentage from previous years (BPS Jakarta, 2021). Even the Governor of Jakarta once said that the total number of vehicles in Jakarta is more than the total population of around 11 million people (Muryono, 2021).

In contrast, a statistic from BPS shows that the number and growth of Transjakarta Bus Passengers by Corridor in 2020 decreased 52,1 % compared to the previous that had 264 million passengers for one year (Rizaty, 2021). The number of train passengers decreased in 2020 to only 80 million compared to the previous year. This data may be biased because in 2020, pandemic began in Indonesia. However,

Jakarta has a mission to turn back and improve the function of public transportation as the main mode of citizen mobility. On the other hand, we take Salatiga City, a small city and not the center of the economy in Central Java, as a comparison. The number of motorcycles in this city in 2020 was 120 thousand increasing from the previous year. Then, the number of cars in 2020 was 19 thousand (BPS Jateng, n.d.). If we compare to the population of Salatiga City in September 2020, which was 192,322 people, more than 70% of the population own a private vehicle (BPS, n.d.). While the number of in-city transportation in 2020 was 421 vehicles, it noted that in Salatiga City, there is no train (BPS Salatiga, 2021). The analysis above shows that many cities in Indonesia still need to increase the quantity and quality of public transportation.

Moreover, the existing public transportation system in Indonesian cities still does not integrate. There are still many modes of public transportation in some cities that stop at any place, opening a special point. Public transportation generally picks up passengers where they stand and drops passengers where they want. In addition, access from the airport to the train station is still far in some cities. Then, one of the reasons that people prefer choosing choose the private vehicles is that important points from every corner of the area do not have easy access to go. For instance, a resident who wants to use public transportation from his home to the sub-district office sometimes has to wait an hour for the departure time or the difference between the arrival of certain public transportation routes and the next vehicle.

D. Conventional System

If we look at Indonesia's transportation problem, we must differentiate between metropolitan and non-metropolitan cities. The availability or quantity of public transportation in metropolitan cities can be considered sufficient compared to non-metropolitan cities. Besides the quantity that needs to be increased the transportation system is not yet fully technology-based. Payment mechanism commonly is based on conventional payment, even using money directly as a transaction

tool. The ticketing mechanism is still not fully implemented on public transportation, especially for using the e-money card as a payment method.

Jakarta may be the first city that promotes Jak Lingko as electronic payment for public transportation payment. However, it needs to be expanded again for all kinds of existing transportation modes and not only for the Jakarta area but also can be operated in other cities. Then, the big data concept does not fully enter the public transportation system. Take Jakarta as an instance, people only know the table schedule of arrival and the route based on poster paper, and the schedule sometimes may be late. It needs a real-time information system that informs passengers how many minutes the bus will arrive at a certain point. So, the position of every public vehicle, be it a bus or train, is recorded by a system that can be seen in real-time.

In some non-metropolitan cities, *angkot* or shared taxi is still the main mode of transportation. *Angkot* are private cars that are used as public transportation. Take Semarang city as an example, *angkot* still become the main public transportation besides the bus. As the capital city of Central Java, the transportation system of Semarang city is still lagging behind Jakarta. Sustainable and advanced transportation infrastructure needs to be implemented in several cities in Indonesia besides Jakarta, especially big cities that are still experiencing traffic congestion. The infrastructure development that will be carried out also needs to be studied in-depth so that the existing infrastructure is effective and not just frenetic.

E. Not Inclusive and Comfortable Environment

One of the factors of public interest in using public transportation that is the convenience factor that has not been obtained. Service, accessibility, safety, and cost can indicate how well the transportation system is (Aminah, 2018). For instance, disabled people do not get comfortable facilities in entry or space in the mode of transportation. Public transportation such as buses in many cities in Indonesia is not yet friendly for people with disabilities by providing special spaces.

Likewise, the public transportation infrastructure does not provide toilets for disabilities, for example. Then, detailed designs such as seats sometimes still do not consider comfort for passengers. The easiest example is a seat for economy class train passengers. The design of the long seats facing each other in the economy class train makes the long-distance passengers feel less comfortable a detailed design needs to get attention.

Moreover, based on the Jakarta Transportation Safety Board (DKTJ) report, one of the common complaints about Jakarta transportation throughout 2021 is the length of the headway of public transportation, which affects the accumulation of passengers at the bus stop or station (Wibowo, 2021). Before the pandemic, the Minister of Transportation stated that the percentage of public transportation passengers was about 33%, still much less than private transportation users (Wiryo, 2017). This problem requires innovation and strategy from policymakers on how to change the paradigm in society to have a desire to use public transportation instead of private, accompanied by an increase in the quality of service and comfortable facilities.

F. Solution and Recommendation for the Public Transportation System in Indonesia

1. Sustainable Transportation System

Transportation infrastructure has a critical role in the economic development of Indonesia. The transportation system is not only a social means that connects people from one place to another but also a means to open their territory from isolation and backwardness (Qodriyatun, 2012). A sustainable transportation system and infrastructure cannot only overcome various problems such as congestion, vehicle accidents, environmental pollution, and so on, but also stimulate development and encourage equitable regional development in Indonesia.

Jakarta achieved the Sustainable Transport Awards (STA) 2021 in MOBILIZE 2020 virtual conference (Sandiputra & Inggita, 2020). This achievement of course deserves to be appreciated. However, the fact

of daily traffic congestion still appears. Let's talk about Indonesia as a country. We also must pay attention to other cities. Through smart mobility, the goal is to reduce the use of private vehicles. Initially, it needs government policy to regulate the number of owned vehicles. In 2020, the Bureau of Statistics (BPS) recorded that the total population of vehicles in Indonesia was more than 133 million units (BPS, n.d.). Take Singapore as an example. The government regulates that before buying a car, people need to have a Certificate of Entitlement (COE), a license to own a car issued by the Land Transport Authority (LTA). It may be challenging to apply to all cities in Indonesia, but we can imitate this policy in big cities with a high percentage of private vehicles.

To implement sustainability of transportation systems and infrastructure, several points affect the sustainability foresight based on IPE or Infrastructure Performance Enhancement, such as accountability, certainty, cost-effectiveness, participation transparency, and others taken by stakeholders (Gharehbaghi et al., 2020). One of the indicators of sustainable transportation infrastructure is built based on public transportation using electric energy such as buses and trains to mobilize people far more efficiently than private vehicles, where an electric vehicle has less pollution and carbon footprints (Mead, 2021). To realize a sustainable transportation infrastructure, there are some breakthroughs:

a) Smart Mobility

There are some innovations or based-technology solutions that can be implemented in smart mobility:

1) Congestion Traffic Detection

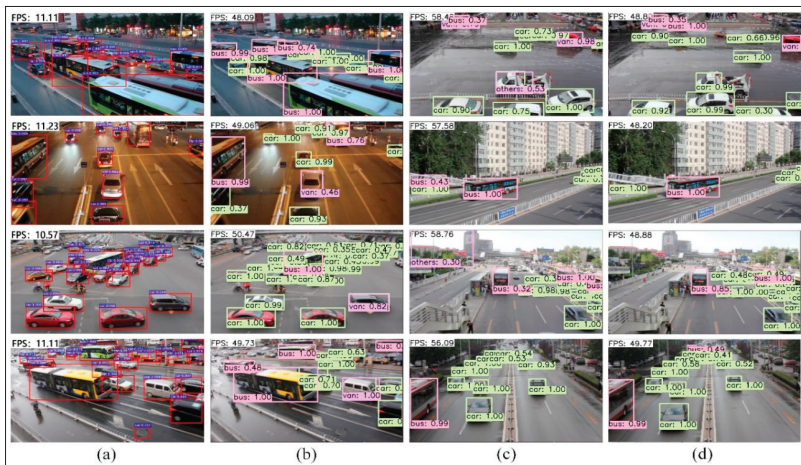
Traffic signs are critical equipment affecting the traffic congestion in the roadway. The traffic congestion will happen long during busy periods, especially departure and return from the workplace. Through a congestion detector, it can set the traffic sign based on the congestion. The length of time for changing traffic signs in congested and lost traffic conditions can be adjusted differently to

avoid prolonged congestion. Many cities in Indonesia have applied CCTV near the traffic sign. This camera can detect congestion by image processing using computer vision and deep learning, as shown in Figure 15.1. Through this technology, vehicles passing a crossroads can also be counted. Many studies have proposed various technologies to achieve this goal. This concept may not yet be applicable in many points and cities, but at least we start at some points prone to traffic congestion in big cities.

The congestion traffic detection algorithm can be seen in Figure 15.2 as an instance. First, we have a video sequence as the input of vehicle number detection. Then, image processing utilizes image processing to estimate the number of vehicles and traffic density. The image processing result can classify the traffic congestion to apply a dynamic traffic sign based on the traffic congestion degree.

2) Emergency Routing

As previously mentioned, the number of private vehicles in Indonesia is huge, and congestion in traffic often occurs. As a



Source: Zhang et al. (2019)

Figure 15.1 Vehicle's Detector Using Image Processing

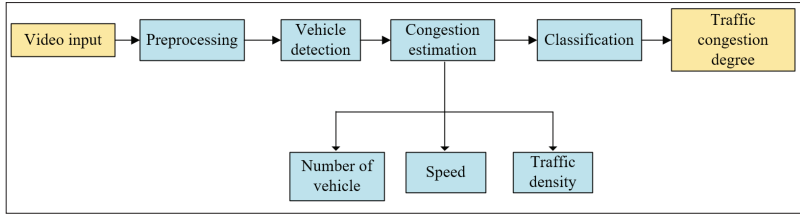
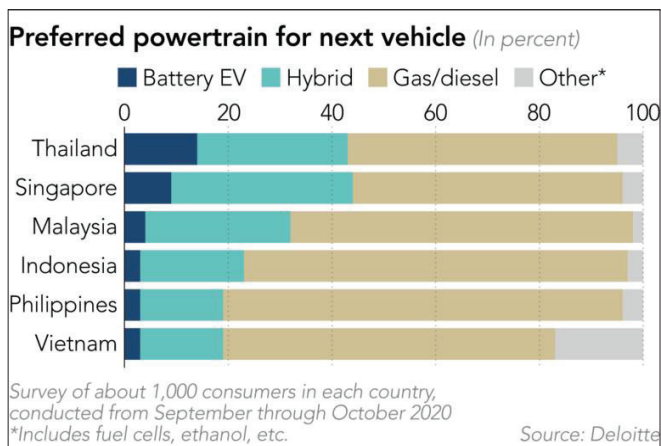


Figure 15.2 Vehicle's Detector Algorithm

follow-up to previous technology, the government can create an information system to give alternative path references in cities when there is congestion or accident. This technology can be combined with the Google Maps feature where Google Maps has a drawback drawback of giving information about congestion from devices if the devices activate their GPS in smartphones. This proposed technology can provide adapted route guidance and dynamic traffic signal timing.

b) Sustainable Vehicle Promotion

The Ministry of Transportation of Indonesia stated that in mid-2021, there were 14 thousand electric vehicles (Primadhyta, 2021). The electric vehicles consist of 1,656 cars, 262 three-wheeled vehicles, 12,464 electric motorcycles, 13 buses, and five freight cars. It is still below 1% of the percentage of vehicles spread in Indonesia. In contrast, the number of public electric vehicle charging stations has reached 187 units spread over 155 locations on Java, Sumatra, and Sulawesi. The government needs to make a policy that supports the use of electric vehicles. At least the buses or cars that the government uses as public transportation and government operational service vehicles use electric vehicles. In tIndonesia, the largest country in the ASEAN region, still depends on gas or diesel for the powertrain. The use of battery EV based on a survey around the end of 2020 is below than Thailand, Singapore, and Malaysia as shown in Figure 15.3. The government policy can accelerate the use of electrical energy



Source: Loh & Sugiura (2021)

Figure 15.3 Powertrain Sources in ASEAN Countries

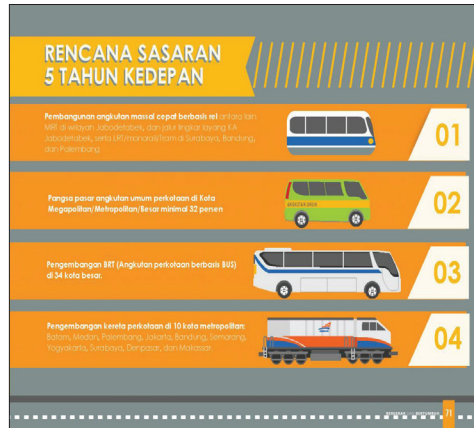
for powertrain through lower taxes on the sale and ownership of low-emission vehicles.

2. Integrated Public Transportation

The transportation system of big cities in Indonesia is still fragmented, which causes passenger journeys to be longer, less comfortable, and more expensive. The operating path of each type of public transportation mode is still independent. Even every transportation mode stops carelessly because there is no standard stopping place except in some big cities like Jakarta. Here we will map out several points that need to be carried out by policymakers to realize the integration of public transportation.

a) Establishment of Public Transportation Stops

The majority of landmass transportation in Indonesia is *angkot*, bus, train, and MRT as shown in Figure 15.4. However, *angkot* and buses are almost in all cities in Indonesia. The government needs to make regulations that not all types of mass public transportation can stop



Source: Kominfo (n.d.)

Figure 15.4 Mass Transportation

recklessly. They can only stop at a certain point according to what has been determined. For instance, each *angkot* with a certain route can only stop at 50 points where passengers are waiting. When there is no passenger, the car keeps going. Each stopping point is made as a marker regarding transportation that passes through the place accompanied by the route and time of arrival as shown in Figure 15.5. The problem is that individuals own public transportation in Indonesia, but not all public transportation modes are owned or under the government. To this end, the government may create a regulation that only transportation modes obtaining official permission from the government can operate. The income they get must be submitted to the government and they will get a fixed income every month regardless of how many passengers they get.

3. Integrated Route and Schedule

People need integrated public transportation to get an effective route and time. Stakeholders must provide a certain schedule of specific public transportation. Integrated public transportation is designed based on how demand-responsive services are arranged and the

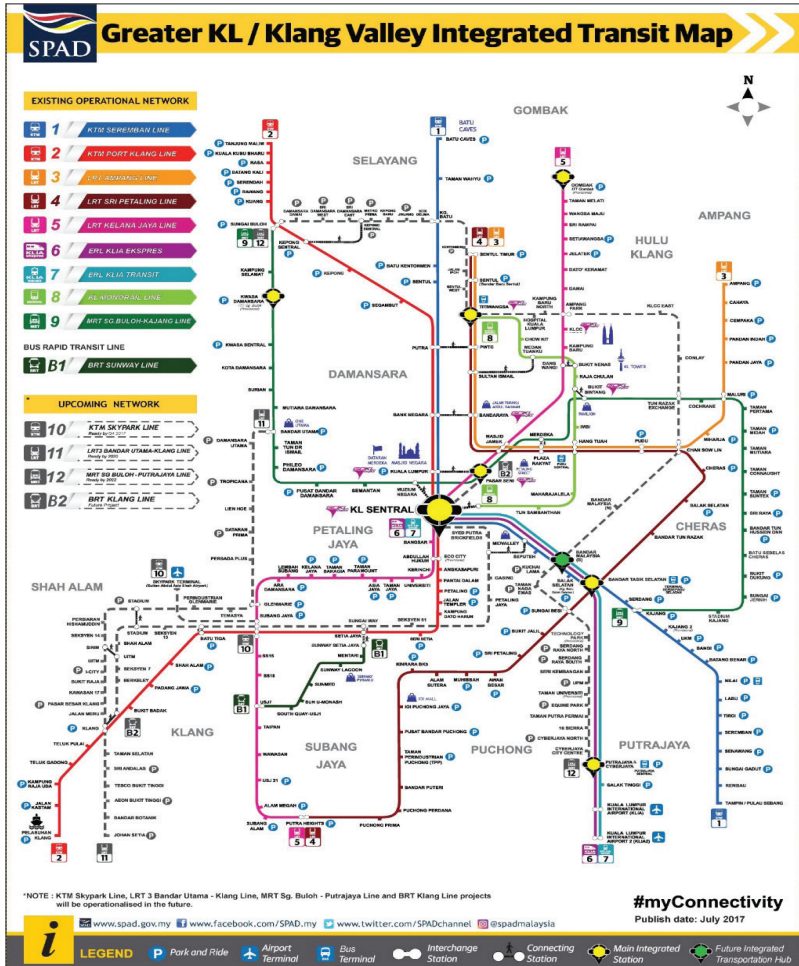


Figure 15.5 Stopping Point with Its Schedule and Route in Taiwan

frequency of a route from public transportation modes to a certain point (Hall et al., 2008). First, they can map the busy time route of specific public transportation. On busy routes or with many passengers, a type of public transportation passes the more stopping point each hour. Instead of having a long route not integrated with other modes of transportation, it is very important to rearrange the modes of transportation that are integrated. Each city in Indonesia needs to design integrated public transportation, including buses, and MRT as shown in Figure 15.6.

4. Centralized Data Information

Public information about transportation services is not yet easily accessed by the community. The government needs to build an information system for public transportation. This information system includes all information about the route and schedule of public transport in all cities in Indonesia, including buses, trains, or



Source: klia2.info (n.d.)

Figure 15.6 Integrated Transit Map in Malaysia

MRT. In Google Maps, we may find a route from Senayan to Monas using some transportation such as Bus or MRT. However, if we see from Magelang Square to the mayor's office, you will not find public transportation route. Centralized information about the schedule and

route of all public transportation is critical to be defined through digital information such as smartphone applications.

One of the problems is that not all public transportation in Indonesian cities has a specific route code. Therefore, all types of public transportation in various cities must be attached to a code for easy identification. Figure 15.7 shows digital information system for public transportation in Taiwan. This application allows us to find buses by route number or the stopping point name. Moreover, this information is real-time, so public transportation informs its current location to be detected by the information system. This application system gives information about real-time schedules for buses and MRT, regular trains, and LRT.

Afterward, most payment conducted in public transaction uses cash in non-big cities in Indonesia. Big cities such as Jakarta, Surabaya, and others may apply non-cash payments or smart cards. Jakarta may

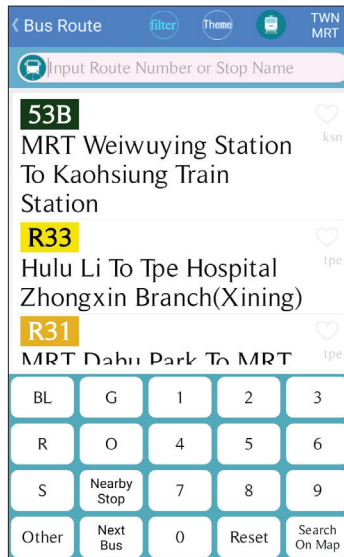


Figure 15.7 Example Digital Information System for Public Transportation

lead to public transportation payment through the *Jak Lingko* card as shown in Figure 15.8, but it only can be used and applied in Jakarta area. We need a smart card such as *Jak Lingko* in Jakarta to be able to be used and applied in all cities in Indonesia and for all transportation. The Indonesian Ministry of Transportation needs to serve smart cards for public transportation payments for buses, trains, MRT, and etc. Take Taiwan as an instance, they have smart cards such iPass and EasyCard for all transactions, not only for transportation payment but these cards can also be used for minimarket payment and others. This card can be used not only for short-distance public transportation but also for long-distance or inter-city transportation.

These smart cards can help people whenever they travel and avoid the *calo* (broker) that is still rife in the sale of transportation tickets in Indonesia. The balance can be topped up through minimarkets or authorized agents near public transportation stations. It can also give precise information about the pattern of community use when using public transportation every day in various modes and regions.



Source: Arjanto (2019)

Figure 15.8 Jak Lingko Card

5. Inclusive and friendly public transportation

Based on data from the 2015 Inter-Census Population Survey (SUPAS), BPS recorded 8.56% of the population with disabilities (BPS, 2016). It indicates that we should pay attention to them, especially their mobility in public transportation. Indonesia may be far in facilitating disabilities compared to developed countries. However, we can start to make them comfortable when using public transportation. Many public transportations do not provide a space or seats for people with dis. In-city and inter-city buses must provide easy access from the bus stopping point to enter transportation. Likewise, the intercity destination train modes managed by the Indonesian Railways (KAI) must be more inclusive in providing easy and convenient access. Some points in big cities like Jakarta may already provide these services, but they need to be improved and augmented in other cities. Each



Source: Alamy Stock Photo (n.d.)

Figure 15.9 A Bus with Inclusive Access for Disabilities

bus or train should be accessible for parents, pregnant women, and disabilities as shown in Figure 15.9.

Table 15.2 Glossary of Terms Used

Term	Explanation
Society 5.0	A society centered on balance and integration through technological advancement to solve social and economic problems
Artificial intelligence	Systems or machines imitate human intelligence to do tasks and improve their abilities iteratively
Big data	A study to analyze and extract information systematically from massive data sets
Commuter	Workers who regularly travel through a route each day
Image processing	A method to process digital images through an algorithm to obtain valuable information or perform some operation

G. Conclusion

Indonesia, a country with a big population and wide area, has huge mobility for society. However, traffic congestion often occurs in everyday lives, especially in big cities. It denotes that public transportation services are not satisfactory or do not yet attract the interest of citizens to use them. Based on the various problems that have been analyzed, this chapter proposes several ideas that can serve as references for a sustainable and progressive public transportation system. We map them with several points such as the development of sustainable transportation system designs, integrated public transportation, centralized data information, and inclusive and friendly public transportation. The existence of well public transportation system will help the mobility of citizens in an efficient and environmentally friendly manner and can be a long-term investment for the government.

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