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BRT Transjakarta: Phasing in, Performing and Expanding a New System within a consolidated urban area

Report for the “Inclusive and sustainable smart cities in the framework of the 2030 Agenda for Sustainable Development” Project

Franco Jauregui-Fung

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Draft version

Franco Jauregui-Fung

German Institute of Development and Sustainability (IDOS)

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Franco Jauregui-Fung is a researcher in the programme “Transformation of Economic and Social Systems” at the German Institute of Development and Sustainability (IDOS).

E-mail: franco.jauregui@idos-research.de

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Tulpenfeld 6, 53113 Bonn
E-mail: publications@idos-research.de
http://www.idos-research.de

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Abbreviations

ABPN	National Budget Allocation
ADB	Asian Development Bank
AFC	Asian Financial Crisis
A-S-I	Avoid-Shift-Improve
BAPPENAS	Ministry of National Development Planning
BAU	Business-as-Usual
BEV	Battery Electric Vehicle
BLU	Public Service Entity
BMZ	German Federal Ministry for Economic Cooperation and Development
BP	Management Agency
BRT	Bus Rapid Transit
BUMD	Regional Owned Enterprise
BYD	Build Your Dreams
CFF	C40 Cities Finance Facility
CMEA	Ministry for Economic Affairs
CNG	Compressed Natural Gas
Dishub	Transportation Agency
DKI	Special Capital City Region
DNPI	National Council on Climate Change
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFC	Global Financial Crisis
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
IDOS	German Institute of Development and Sustainability
IDR	Indonesian Rupiah
IGIF	Indonesian Green Investment Fund
ITDP	Institute for Transportation & Development Policy
IMF	International Monetary Fund
LCEV	Low-Carbon Emission Vehicle
LRT	Light Rail Transit
LVC	Land Value Capture
MaaS	Mobility as a Service
MEMR	Ministry of Energy and Mineral Resources
MoEF	Ministry for the Environment and Forestry

MoF	Ministry of Finance
MoHA	Ministry of Home Affairs
MoI	Ministry of Industry
MoT	Ministry of Transport
MPWH	Ministry of Public Works and Housing
MP3EI	Masterplan for Acceleration and Expansion of Indonesia's Economic Development
MSOE	Ministry of State-Owned Enterprise
MRT	Mass Rapid Transit
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organisations
NOx	Nitrogen Oxides
PHEV	Plug-In Hybrid Electric Vehicle
phpdt	Passengers per hour per direction of transit
PIP	Indonesian Investment Agency
PM	Particulate Matter
PPP	Public Private Partnership
PSC	Project Steering Committee
PTA	Public Transport Authority
RAD-GRK	Local Government Mitigation Actions
RAN-GRK	National Mitigations Actions
RENSTRA	Strategic Plans
RKP	Government’s Work Plan
RPJMN	National Medium-Term Development Plan
RUEN	General Planning of National Energy
SDG	Sustainable Development Goal
SUTRI	Sustainable Urban Transport Initiative
TCO	Total Costs of Ownership
TDM	Transport Demand Management
TOD	Transit-Oriented Development
USD	United States dollar
UNEP	United Nations Environment Programme
UPT	Technical Implementation Unit
WHO	World Health Organization

1 Introduction

In an effort to reduce congestion levels and greenhouse gas (GHG) emissions, many cities in emerging economies are betting on mass transit systems. However, the phasing-in of these systems within already consolidated and heavily urbanised areas is not easy, as they represent the removal of existing bus-like systems and paratransit, the reduction of benefits for car users, and require high upfront investment costs. One of these systems is bus rapid transit (BRT), which consists of segregated lanes exclusively for buses to transport many people in the fastest way and avoid traffic congestion, but at a comparatively more affordable capital cost than railway-based systems. This innovative system appeared as a Global South solution in Latin America and has become a major referent for the implementation of more affordable mass transit solutions at a faster speed.

However, many cities struggle to implement BRT due to a series of challenges from the need of an institutional framework and financing to the managing of competing transport modes and public opposition from car users and informal bus operators. When these challenges are not solved, already implemented BRT systems struggle to successfully perform and expand their network to increase the service coverage. This is particularly the case due to the design of BRT components (e.g. the quality of the infrastructure, vehicles and service) that fail to meet users' expectations and needs. For this reason, many BRT systems do not reach their full potential in order to improve the mobility needs of citizens.

As one of the cities inspired by Bogota's Transmilenio, Jakarta has implemented the largest BRT system in the world: Transjakarta. This city, capital of the Southeast Asian nation of Indonesia and one of the world's fastest economies, has not been able to align its accelerated development with sustainable transit. In fact, Jakarta started its rapid urbanisation growth during the second half of the 20th century, before the consolidation of its mass transit systems. In contrast, the city followed car-oriented planning strategies that, together with fuel subsidies and the increase of income among citizens, have led to high motorisation levels of private vehicles (cars and motorcycles) and congestion of its roads in polluting vehicles that represent a hazard to public health.

Under this scenario, Transjakarta represents a solution to reduce the increase of motorisation and the shift in favour of sustainable mobility through the use of transit. For this reason, this BRT system will be studied in order to understand how Transjakarta has been able to face the challenges during the phasing-in stage, but also how it has managed to improve its performance and expand its network.

This research is structured in four sections. First, the challenges for phasing-in, good performance and expansion of BRT systems will be introduced. Then, the case of Jakarta is presented, with key urban and mobility characteristics and governance within the transport sector. Then, this report will study how Transjakarta faced the different challenges during the implementation of the system, including the involving of stakeholders and managing of upfront investment costs. This section will also present the improvements Transjakarta has gone through to achieve a better performance and expand its network in recent years. The following section will assess the system based on a series of mobility and social indicators to see the impact of Transjakarta. This will be followed by the co-benefits of the system, such as the reduction of GHG emissions, industrial development and technological learning, the electrification of the fleet and impact on property prices. Finally, this study will close with some conclusions and recommendations based on the findings.

This study is one of the knowledge products from the research project *Inclusive and sustainable smart cities in the framework of the 2030 Agenda for Sustainable Development* carried out by the German Institute of Development and Sustainability (IDOS) and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). Within the framework of

the Big Push for Sustainability, this paper will introduce the challenges and co-benefits of BRT systems in emerging economies. IDOS would like to acknowledge the financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ).

2 Challenges for the phasing-in, good performance and extension of BRT systems

BRT systems give the priority to buses through a segregated lane to transport many people in the fastest way and avoid traffic congestion, at a more comparatively affordable infrastructure cost than those of other mass rapid transit (MRT) systems, such as light railway transit (LRT) and metro. During the 1970s, the first BRT prototype in Latin America came from Lima, with the introduction of a central segregated lane along a main urban freeway. The prototype inspired policymakers from Curitiba (IEG, 2015). In this city, the first modern BRT system was implemented in 1972 with the *Rede Integrada de Transporte* that encouraged mixed-use and high-density development along five main corridors (Mejía-Dugand, Hjelm, Baas, & Ríos, 2013; Rodriguez & Vergel Tovar, 2013). After its implementation in other Brazilian cities, Quito became the first city outside Brazil to phase-in BRT in the 1990s, but it was Bogotá's Transmilenio, opened in 2000, the one that made the system internationally recognised and replicated in other cities in the region (Mejía-Dugand et al., 2013). Today, BRT systems are found in 181 cities worldwide, with most of them in Latin America with sixty-one cities and followed by Asia with forty-five (BRTData, 2022).

The advantage of BRT systems is the combination of infrastructure, such as segregated busways, stations and terminals, with organised operation and intelligent technologies that provide a higher-quality service with standard bus operation (Hidalgo & Graftieaux, 2008). Fixed stations and terminals provide more organised boarding and alighting, with fixed routes and frequencies, while also enabling pre-board fare collection. Feeder services also contribute to expand the coverage area of the system (Ernst, 2005; Primatama, 2018). In addition, BRT, as a more reliable system, has improved the image of bus service, with higher speed, frequency, passenger capacity and comfort, comparable qualities with LRT and MRT modes (Deng & Nelson, 2011). Furthermore, when combined with land-use planning, BRT can provide significant opportunities for urban restructuring and growth towards compact and mixed urban growth along corridors. This can contribute to increase real estate prices along BRT stations (Cervero & Dai, 2014)

As a result, it has become a popular option for local governments, due to its efficiency, but also flexibility and affordability (Mahadevia, Joshi, & Datey, 2013). For a range between twenty and forty thousand passengers per hour per direction of transit (phpdt), metros and high-level BRTs provide quite similar capacities. However, high-level BRTs have construction costs of five to twenty million USD per kilometre, whereas the construction of metro systems costs from thirty up to 160 million USD per kilometre (Hensher & Golob, 2008). Despite these advantages, some local government have also found barriers to successfully implement BRT systems in their cities, but also to achieve high performance levels and extension of the network.

Despite the benefits of BRT regarding its flexibility, affordability, faster construction and expansion, its phasing-in requires complex planning on different sectors that go beyond the technical specifications and design of the infrastructure, such as financial, institutional and political issues (Nguyen & Pojani, 2018). As well, its implementation into already consolidated urban areas results particularly challenging because the insertion of exclusive busways requires the removal of lanes allocated to private cars. Due to these challenges, some systems have not been able to expand beyond a single corridor, which reduces the impact of BRT to increase transit ridership and reduce traffic congestion. In other cases, some systems have been even

dismantled (Nguyen & Pojani, 2018). This section will explain the main challenges that the phasing-in, good performance and extension of BRT systems face, especially in emerging economies, found by authors in the field (Lindau, Hidalgo, & de Almeida Lobo, 2014; Nguyen & Pojani, 2018; Wu & Pojani, 2016).

2.1 Institutional and legislative restructuring

Due to the combination of weak administrative arrangements, lack of adequate legislation in favour of BRT, limited planning capacity and lack of coordination between land-use and transit planning, local governments struggle to exploit the complete benefits of BRT systems (Nguyen & Pojani, 2018; Wu & Pojani, 2016). This is especially relevant when transit planning is divided across different government agencies within a single metropolitan area that do not coordinate between each other (Nguyen & Pojani, 2018). Moreover, when some cities do count with public transport authorities (PTAs), these lack of autonomy, technical and financial capacities. This is worsened by the lack of aligned interests between different city official and relevant stakeholders (Lindau et al., 2014; Nguyen & Pojani, 2018).

Regarding BRT specifications, this lack of coordination is particularly important because not a single company can provide all the necessary elements for BRT implementation, especially when cities do not count with specialised BRT agencies, consultancy services and local companies (Nguyen & Pojani, 2018). This can result in the delay of projects' implementation (Wu & Pojani, 2016). For this reason, cities in emerging economies end up seeking foreign BRT consultants (Hidalgo & Graftieaux, 2008).

2.2 Political leadership and commitment

For the phasing-in of successful BRT systems, it is essential to have the commitment from city leaders and decision makers, as well as their political will to engage in these projects and take advantage of the current momentum of BRT worldwide (Nguyen & Pojani, 2018; Wu & Pojani, 2016). Leadership is necessary to convince citizens about the positive impact of BRT projects, unlock the necessary resources for planning, mitigate potential risks during the planning and implementation and ensure their credibility (Hidalgo & Graftieaux, 2008; Wu & Pojani, 2016). This type of top-down approaches can reduce conflicts with different government agencies (Hidalgo & Graftieaux, 2008; Lindau et al., 2014), but the reliance of a BRT project on a single mayor can also represent the risk of its discontinuation after the change of administration at the end of an electoral period (Nguyen & Pojani, 2018; Wu & Pojani, 2016). For this reason, although top-down approaches can be advantageous, BRT projects with a single name should also be discouraged in favour of engaging public participation and multiple stakeholders beyond mayors' electoral periods (Hidalgo & Graftieaux, 2008; Wu & Pojani, 2016). This is especially relevant when expanding the network of already implemented BRT systems.

2.3 Public participation and image promotion

As BRT phasing-in may disrupt the *natural order* of car-centric design, it is convenient to set a good communications campaign and generate community engagement. Lack of public participation and information on the advantages and realistic expectations of BRT can jeopardise the phasing-in of the system (Nguyen & Pojani, 2018; Wu & Pojani, 2016). This can contribute to educate citizens on the benefits and limitations of BRT (e.g. due to the capacity of buses, passengers should not expect that there will be available seats during the entire ride) (Muñoz & Gschwender, 2008). Public participation campaigns and engagement can minimise opposition from the largest groups, such as car owners and private bus operators. Planners

should be able to find spaces for negotiation and compromise with these groups to reduce risks of failure during the phasing-in. A lack of a distinctive image and clear information can also affect a smooth implementation and future performance of BRT. Therefore, it is important to provide promotional campaigns to generate awareness on the benefits of BRT over other transport modes, particularly private cars and motorcycles. This can also reduce negative publicity on the media during the implementation stages, due to the construction works (Nguyen & Pojani, 2018; Wu & Pojani, 2016).

2.4 Managing of competing transport modes

BRT systems involve the removal of existing lanes allocated to mixed traffic in favour of corridors for BRT only, as well as the removal of existing bus lines over the same routes to concentrate ridership on BRT services. This represents two types of different challenges. The first consists of the opposition from private car and motorcycle owners, as the removal of lanes can be seen as interfering with the *rights* of car owners, who belong to the most privileges sectors (Kumar, Zimmerman, & Agarwal, 2012). This is particularly the case in countries with domestic car industries (Nguyen & Pojani, 2018), as private vehicle sales represent substantial tax revenues (Lindau et al., 2014). Retail owners can also oppose BRT because of the fear of losing customers due to the removal of street parking (Nguyen & Pojani, 2018). For this reason, it is also necessary to provide complementary policies to discourage car use in addition to BRT phasing-in, as well as the promotion of the benefits of this system.

The second challenge comes from the opposition from existing bus operators, especially in urban areas with consolidated paratransit networks that represent the highest share of transit daily trips, provide jobs to a numerous number of people who live on the daily profit and have a strong influence when decision making (Asimeng, 2021; Jauregui-Fung et al., 2019). It is necessary to include these informal operators in the participatory process of BRT implementation and as part of a new large-scale ownership structure (Muñoz & Gschwender, 2008; Wu & Pojani, 2016), as they can delay or even contribute to the failure of the phasing-in. Their resistance and opposition may be due to the loss of autonomy and flexibility over existing networks, financial and economic risk avoidance, and lack of trust in the government (Asimeng & Heinrichs, 2021).

In cities with already implemented BRT systems, these can fail to perform due to the existence of other transport modes, particularly railway, which can have a better image in comparison to BRT (Nguyen & Pojani, 2018; Wu & Pojani, 2016), especially when this has been poorly built. The lack of intermodal integration through facilities between BRT and other transport modes can negatively impact its performance and network expansion (Nguyen & Pojani, 2018). The integration should also include cycling parking, as these users may perceive BRT as a rival over already scarce road space, instead of as a complementary transport mode (Lindau et al., 2014; Wu & Pojani, 2016). Therefore, additional policies should also be considered, such as enforcement of traffic rules, parking management, congestion pricing, limitation of licenses to other transport modes along the same BRT routes and the improving of the urban environment in favour of active transport (Wu & Pojani, 2016).

2.5 Financing

Although BRT represents a more affordable alternative in comparison to other mass transit systems, it still embodies large upfront public investment for local governments, from the building of the infrastructure to the provision of road space, bus depots and terminals (Nguyen & Pojani, 2018). This is significantly challenging in urban areas that have not had any kind of institutional systems before and have only relied on free-market, informal transit modes without subsidies

nor financing schemes. Therefore, local governments may struggle to find new and innovative funding sources, such as public private partnership (PPP) schemes, transfer from regional or national governments, taxes on fuel and private vehicles, or land value capture (LVC) through transit-oriented development (TOD) (Nguyen & Pojani, 2018; Wu & Pojani, 2016)

Additional financing challenges are related to the poor planning of the BRT network and the supply of service in peripheral, low-density areas that will not provide revenue returns (Nguyen & Pojani, 2018; Wu & Pojani, 2016). Although the hiring of previously existing private operators may be convenient (Hidalgo & Graftieaux, 2008), a large size of operators may affect the economics of scale. As well, operators need some sort of incentives for operation along the entire network and not only on the most profitable corridors (Wu & Pojani, 2016). This type of incentives should also consider the change of the frequency of salaries from a daily basis to a biweekly or monthly frequency, and the changes it implies for the lives of operators. Funding challenges also include the continuous maintenance of the system to avoid its deterioration without the need of raising fares, which should be maintained affordable to ensure the ridership levels of the system (Wu & Pojani, 2016), especially by low-income passengers. This implies that the system should receive some kind of subsidies to compensate for low fares, or diversify the revenue sources apart from transport operations.

2.6 Design of BRT components

Poorly designed BRT components (lack of central lane segregation, integrated network, special vehicles, technology for information display and pre-board fare payment, raised platforms, and trained staff) can affect the performance of the system. The quality of the components should start from the first implemented corridor to set a high standard of the system and ensure its expansion. Poorly designed components also restrict the physical integration with other transport modes, from railway and buses through intermodal stations, to active transport through bicycle parking facilities (Nguyen & Pojani, 2018; Wu & Pojani, 2016). Stations should also consider the potential for station area and corridor development through TOD strategies. As well, the system should include feeder services to reach peripheral, high-density areas in the fringe of the city, where corridors cannot be implemented due to the lack of infrastructure. Existing routes should also be considered (Muñoz & Gschwender, 2008) to avoid competition and parallel routes in favour of the increase of the coverage area by public transport.

3 Jakarta as a case study that faced these challenges

Jakarta represents an interesting case, as it has been able to face the aforementioned challenges to implement its BRT system and has been able to perform and expand its network throughout the years in such a way that today it has the largest BRT network in the world. This section will expose some of the particular urban, social and mobility conditions of this urban area.

3.1 Urban and social characteristics

Jakarta is the capital of Indonesia, the fourth most populous country located in one of the world's most dynamic regions (Abiad, Farrin, & Hale, 2019). It receives the official name Special Capital City Region (DKI Jakarta) and has been the country's centre of trade culture for centuries. The city has grown at a rapid pace in the last thirty-five years, which has led to the sprawling of the urbanised area. Today, DKI Jakarta is a megacity with a population of 10.6 million inhabitants and an annual population growth rate of 1.19 per cent (BPS-Statistics, 2020). Furthermore, due

to the commuting trips from the surrounding cities, the number of dwellers can swell to approximately twelve million people (Angelina, Vallée, & Louen, 2017).

The city receives the same status as a province, governed by an elected governor. DKI Jakarta is divided into five administrative areas, each one with their own mayor: Central Jakarta (Jakarta Pusat) that houses 8.79 per cent of the population, West Jakarta (Jakarta Barat) with 24.53 per cent, South Jakarta (Jakarta Selatan) with 21.45 per cent, East Jakarta (Jakarta Timur) with 27.83 per cent, and North Jakarta (Jakarta Utara) with 17.17 per cent of the population. In addition, there is one administrative regency headed by a regent: the Thousand Islands (Kepulauan Seribu) that house 0.23 per cent of the city's population (BPS-Statistics, 2020). The average density of Jakarta is 15,900 people per km^2. However, West, Central and East *Jakartas* surpass this average with 20,813, 17,719 and 16,080 people per km^2, respectively, whereas Kepulauan Seribu has an average density of only 2,387 people per km^2 (BPS-Statistics, 2020).

In 2019, the annual gross domestic product (GDP) per capita in Jakarta was 174,137 thousand Indonesian rupiahs (IDR), which is equivalent to 17,137 US dollars (USD) (BPS-Statistics, 2019). The minimum monthly wage is 3,940,973 IDR (272 USD). The monthly average net wage of a formal employee is 4,216,379 IDR (291 USD), whereas the monthly average net wage of an informal employee is 2,634,657 IDR (181 USD) (BPS-Statistics, 2020). The economically active population reaches 5,157,878 people, which represents 64.81 per cent of the population from the age of fifteen. From the currently working population (4,836,977 people), 87.23 per cent are involved in the services industry, 12.30 per cent in the manufacturing industry, and only 0.47 per cent in agriculture (BPS-Statistics, 2020). The distribution of the working population is mainly in East, West and South *Jakartas* with 27.5, 24.3 and 21.1 thousand people, respectively (BPS-Statistics, 2020). Unemployment decreased to 6.22 per cent of the population in 2019, with Central, South and North *Jakartas* presenting percentages above the average (7.51, 6.84 and 6.32 per cent, respectively) (BPS-Statistics, 2020).

The sprawling and economic expansion of the city is urbanising almost one-quarter of green open spaces and land with non-urban uses into commerce, housing and industry (Angelina et al., 2017). In addition, the sprawling has led to the formation of the metropolitan region of Jabodetabek or Greater Jakarta, composed by DKI Jakarta and the surrounding cities of Bogor, Depok, Tangerang and Bekasi. This metropolitan region houses 31.5 million people (Razvadauskas, 2018), which accounts for around twelve per cent of the country's population (Angelina et al., 2017). Furthermore, it is expected that, by 2030, Greater Jakarta will overtake Tokyo as the world's most populous region with a total population of 35.6 million people and become the 23rd largest economy globally in terms of GDP (Razvadauskas, 2018). This would make Greater Jakarta the first emerging city to become the largest megacity on a global scale. Such growth may lead Jakarta to a total collapse of their roads if actions are not taken, as it ranks among the most congested urban areas worldwide with commuting trips that exceed two hours per direction (moovit insights, 2021; Saraswati & Ramadhan, 2020).

3.2 Urban mobility evolution

Like many other big cities during the second half of the 19th century, Jakarta had a transit period with a suburban rail system during the 1870s that was followed by steam trams during the 1880s and electric ones during the following decade. In the next decades, Jakarta took over the rural settlements surrounding the urban area without an adequate reorganisation or resettlement, nor an organising system of public transport and roads. Following the independence of the country in 1950, road investment became a priority during the 1960s to give the city a modern look, with a hierarchical road network of major arteries and secondary roads for intra-city travel (Abiad et al., 2019). The city continued its urbanisation process at a rapid pace with the opening of the international airport in 1985 and a car-oriented planning in favour of road infrastructure for private vehicles. This led to the deterioration of Jakarta's public transport, which was already

taken over by informal buses that still accounted for the major shares of daily trips, along with cycling and walking (Van Cleve, 2020), characteristics of Global South cities with low incomes.

During the 1990s, the motorisation levels of the city grew considerably, in face of the lack of an adequate transit response to accommodate the travel demand in a time when incomes per capita were comparatively lower and better transit habits could have been formed (Abiad et al., 2019; Acharya & Morichi, 2007). The lack of investment in transit infrastructure led to dependence on road-based modes, such as buses, unregulated microbuses (*angkots*) and paratransit services provided by the private sector through companies of individual owners that rent their fleet on a daily basis to operators who live on the daily profit (Ernst, 2005). The lack of regulation of these modes allowed the provision of bad services with inefficient routes and an unpleasant travelling experience (Saraswati & Ramadhan, 2020). Moreover, this system was characterised by corruption with the illegal collection of fees by the government and private-sector operatives (Ernst, 2005).

Car-oriented planning was also revealed through international aid priorities that were only interested in funding car-centric infrastructure (Saraswati & Ramadhan, 2020). As a result of the predominance of investment in road infrastructure and lack of adequate transit to cover the travel demand, car ownership levels tripled between 1985 and 2000, while the number of motorcycles grew 3.5 times over the same period. In contrast to this increase, the average occupancy rate of cars went down from 1.96 to 1.75 people per car (Susilo, Tjoewono, Santosa, & Parikesit, 2007). In Greater Jakarta, private and motorcycle ownership levels continued to grow at an average annual growth rate of 19.6% and 8.6% between 2000 and 2008, more than six times the annual population growth in the case of cars, and more than double in the case of motorcycles (Sayeg & al-Rasyid Lubis, 2014). This growth rates comply with private ownership levels of cities with a higher income. In fact, Jakarta achieved in recent years a middle-income city status with incomes that facilitate car and motorcycle ownership (Abiad et al., 2019; Acharya & Morichi, 2007). Between 2010 and 2016, the number of cars in Jabodetabek changed from 2.3 million to 3.5 million. For motorcycles the increase was from 8.7 million to 13.3 million (Farda & al-Rasyid Lubis, 2018). This is explained because two-wheelers remain as more accessible options for middle-to-low income citizens, while cars are more representative in more affluent households (Ernst, 2005).

In an effort to solve this deterioration of Jakarta's urban mobility, and after some failed projects, such as a monorail, the city has pushed in favour of more equitable mass transit systems in recent years (Ernst, 2005). In 2004, Jakarta implemented its BRT system: Transjakarta and became the city's transit backbone. Greater Jakarta also developed a KRL commuter rail network with an extension of 385 kilometres with six integrated lines (Abiad et al., 2019; Farda & al-Rasyid Lubis, 2018). In 2019, the public transport company PT MRT opened its first sixteen-kilometre rail system that runs from central to south Jakarta with thirteen stations (ITDP, 2021).The MRT is set to expand its network in 2027 11.8 additional kilometres. In 2019, the public transport company PT LRT Jakarta also initiated operations with a 5.8-kilometre line to connect the northern and eastern residential suburbs. There are plans to add twenty kilometres to the network by 2027 (ITDP, 2021). Some other measures have been the enacting of weekly car free days and the encouraging of cycling through the planning of sixty-three kilometres of bike lanes (Van Cleve, 2020).

On a national level, the Indonesian government developed the Sustainable Urban Transport Initiative (SUTRI), as a Nationally Appropriate Mitigation Action (NAMA) in 2013. SUTRI links to already existing policies, such as national development plans, national transport master plan, National Mitigations Actions (RAN-GRK) and Local Government Mitigation Actions (RAD-GRK) (Ernst & Young LLP, 2015). Based on the RAN-GRK, actions the government proposes action plans for the transport sector within the Avoid-Shift-Improve Framework (A-S-I) (Adiatma & Marciano, 2020), including Avoid measures, such as the implementation of TOD with guidelines provided by the Ministry of Agrarian and Spatial Planning Regulation No. 16/2017 and

mechanisms and incentives on a local level provided by the Jakarta Gubernatorial Regulation No. 67/2019 (Adiatma, 2020). Shift measures includes the shift towards more efficient transit modes such as BRT systems and non-motorised transport (Adiatma & Marciano, 2020). These measures are incorporated in the General Planning of National Energy (RUEN) (Adiatma, 2020).

Jakarta has won the 2021 Sustainable Transport Award (STA) for its ambitious integrated public transport programme (intermodal and fare-wise) and the plan for the electrification of the bus fleet. This makes Indonesia the first-ever Southeast Asian country to receive this acknowledgment (Nurbaiti, 2020) and shows the interests of the city to improve its urban mobility. Nevertheless, congestion and air pollution still represent significant challenges for the city. Jakarta presents annual losses of 3 billion USD because of congestion (Van Cleve, 2020). In 2019, the Jakarta was ranked as the city with the worst air pollution in the world (ITDP, 2021). Citizens present average wage losses of 62,000 IDR (4.29 USD) a day during travel times in private vehicles, and 18,600 (1.29 USD) for bus users due to the long travel times (Ernst & Young LLP, 2015). More of this information will be detailed in the following sections.

3.3 Governance within the transport sector

There are several governmental entities from the central government involved in transport policy (see Table 1), which can lead to coordination constraints between agencies. The National Development Planning Agency (BAPPENAS) is in charge of the planning processes in coordination with the Ministry of Transportation (MoT) and the Ministry of Public Works and Housing (MPWH). The MoT is responsible for national transport policy that provides guidelines for local governments and the duties are divided between different directorate generals: rail, road, sea and air transport (Adiatma & Marciano, 2020).

Table 1: Roles and responsibilities of ministries involved in transport

Ministry	Role and Responsibility
Ministry of National Development Planning (BAPPENAS)	Constructs national development and transport planning
Ministry of Transport (MoT)	Constructs national transport policy and manage public transport infrastructure operation
Ministry of State-Owned Enterprise (MSOE)	Manages national transport infrastructure and operation of transit and state-owned enterprises (e.g. toll roads and rail)
Ministry of Public Works and Housing (MPWH)	Prepares policy for development of national road and bridges network
Ministry for the Environment and Forestry (MoEF)	Prepares national policy for pollution control and environmental impact management of transport
Ministry of Home Affairs (MoHA)	Regulates development programmes at sub-national level (provincial, city and regency), including local transport
Ministry for Economic Affairs (CMEA)	Develops national economic and fiscal policy, including for transport sector; provides economic policies for urban transport proposed by different ministries
Ministry of Finance (MoF)	Prepares state budgeting, including for road and transit infrastructure
Ministry of Energy and Mineral Resources (MEMR)	Develops energy planning and supply, including for the transport sector

Source: Adiatma & Marciano (2020); Wijaya & Imran (2019)

From the roles divided across the mentioned ministries, policy framework for the transport sector trickles down from the development targets outlined in the National Medium-Term Development Plan (RPJMN) (Adiatma & Marciano, 2020). The RPJMN 2015-2019 prioritises the improvement of urban transit in terms of physical and institutional connectivity to face the urban mobility problems (Adiatma & Marciano, 2020; Angelina et al., 2017). The targets of the RPJMN are authorised by BAPPENAS and are the basis for following national planning documents, such as the government's work plan (RKP), strategic plans (RENSTRA) of the MoT and MPWH, and the national budget allocation (APBN). These documents are the basis of public policy in each transport system (Adiatma & Marciano, 2020).

Decision making within the transport sector heavily relies on central and local governments, with the contribution of some non-governmental and international organisations to raise issues relating climate change mitigation and the implementation of more efficient transit systems (Wijaya & Imran, 2019). In favour of tackling this issues, the National Council on Climate Change (DNPI) was established in 2008 as the main body for policy coordination on climate change. In 2011, the MoF created the Centre for Climate Change Financing and Multilateral Policy to formulate policy recommendations and analyse and implement climate-change financing-related issues. The MoF also authorises the Indonesian Investment Agency (PIP) to finance low-carbon investments in partnership with the private sector. The PIP also intends to create the Indonesian Green Investment Fund (IGIF) as a multi-stakeholder, pooling fund to finance environmental friendly investments through PPP schemes (Ernst & Young LLP, 2015).

This complex structure creates several overlapping interests and coordination difficulties, especially between BAPPENAS, MoEF and MoF has proved difficult (Wijaya & Imran, 2019). In addition, there is still lacking an integrated plan for all transport modes and regions (Adiatma & Marciano, 2020). This has proven more difficult after the Decentralisation Law enacted in 2001, which gives local governments the decision power over local governance aspects and the option of not following central policies. This degree of decentralisation has increased the role of local governments in accessing and managing climate finance. The coordination between national and sub-national actors is ensured by the MoHA, while the MoF aims to provide grants to local governments able to address mitigation actions, although this is still at a very early stage (Ernst & Young LLP, 2015). Other additional important stakeholders are the private sector and civil society organisations as a potential investment sources in transport; the media for the promotion of public awareness and interest in mitigation actions and transparency; and politicians for political will in favour of more sustainable alternatives (Ernst & Young LLP, 2015).

4 Phasing-in, performance and expansion of Transjakarta

In 2004, Jakarta implemented the first BRT system in the country and in Southeast Asia (Ernst & Sutomo, 2010). The initiative came from the governor of Jakarta, Sutiyoso, in a time in which transit was poorly seen in favour of private transport modes (Angelina et al., 2017). In an effort to implement an innovative transit system but without the resources to afford the construction of a metro after the economic crisis of those years, two delegations from Jakarta visited the Latin American cities of Bogotá and Quito in 2003 to learn about their BRT systems. After the visit, Sutiyoso created a task force to implement Jakarta's own BRT in order to provide a better transit services, reduce congestion and greenhouse gas (GHG) emissions. The team was formed by five agencies: transport, public works, park, utilities and planning, and three affected local municipalities. As a result, the first corridor Kota–Blok M of 12.9 kilometres was implemented within nine months between May 2003 and January 2004 (Angelina et al., 2017; Ernst, 2005). The implementation of the system faced some challenges in terms of maintenance, operations and suboptimal service and acceptance from the population (Saraswati & Ramadhan, 2020).

The policies and strategies the government has use to face these challenges have influenced how the system has performed in the following years and these have been crucial for the expansion of the network. These policies and strategies will be explained in the following sections.

4.1 Institutional and legislative restructuring

The planning of the BRT system was supported by the United Nations Environment Programme (UNEP), which had the responsibility for the implementation of the project, and the Institute for Transportation & Development Policy (ITDP) as the executing agency (Sayeg & al-Rasyid Lubis, 2014). UNEP was also in charge of coordination with the Global Environment Facility (GEF), which acted as the catalyst to lend technical assistance for building political confidence and system management (Angelina et al., 2017; Sayeg & al-Rasyid Lubis, 2014). The implementation was achieved through a cooperation between the provincial government of Jakarta, planning agencies and transit providers (Angelina et al., 2017). A Project Steering Committee (PSC) was established with the governor of Jakarta as the chair, a representative from UNEP-GEF, a representative from each DKI Jakarta agency involved in the project, three representatives from Indonesian non-governmental organisations (NGOs), and the Asia Regional Director of ITDP (Sayeg & al-Rasyid Lubis, 2014).

In 2004, Sutiyoso created the public Management Agency (BP) Transjakarta by the Governor Decree No. 110/2003. BP Transjakarta received the capacities to run and plan the BRT system through the contract of operator's consortium, the ticketing of operations to a private company, the handling of revenue to a bank that acted as a trustee, and the operation of feeder service through eight private bus operators. BP Transjakarta fell under the direct responsibility of the governor of DKI Jakarta (Ernst, 2005; PT. Transportasi Jakarta, 2016). In 2006, Sutiyoso modified BP Transjakarta into the Public Service Agency (BLU) Transjakarta, which is a Technical Implementation Unit (UPT) under the Transportation Agency (Dishub) of DKI Jakarta Province. This is regulated in the DKI Governor Regulation No. 48 of 2006 (PT. Transportasi Jakarta, 2016). In this way, DKI Jakarta acts as the main implementation body of the system, while the operational activities are carried out by BLU Transjakarta (Ernst & Young LLP, 2015).

In 2014, Transjakarta changed its status to become a BUMD (Regional Owned Enterprise) and officially changed its name to PT. Jakarta Transportation (PT. Transportasi Jakarta, 2016). Moreover, after years of advocacy by ITDP for open service, Transjakarta became a direct service provider in 2016 (Saraswati & Ramadhan, 2020).

4.2 Political leadership and restructuring

The decision making process for the phasing-in of Transjakarta reflects a top-down approach that resulted in a faster implementation with less initial conflicts between stakeholders and with the vision from Governor Sutiyoso and urban transport plans as the most significant elements of the process. He was re-elected in great part due to his vision to finalise the phasing-in of Transjakarta (Angelina et al., 2017), proving the essential role of political will in transit planning processes. On the other hand, this single top-down approach of a single-person, vision-led decision making resulted in the loss of interest in the development of the BRT system once Sutiyoso finished his management as governor in 2007. As a consequence, the following governments prioritised the construction of the LRT and MRT systems (Angelina et al., 2017).

4.3 Public participation and image promotion

A system like Transjakarta with a segregated lane exclusive for buses represented a new concept in the city. Consequently, the implementation needed a comprehensive communication strategy to gain acceptance among citizens. During the construction of the first corridor, drivers continued using the segregated lanes, situation that continued once operations started (Angelina et al., 2017; Saraswati & Ramadhan, 2020). Sutiyoso conducted communication strategies through advertisements that showed the BRT proposal and led to more public acceptance (Angelina et al., 2017). On the other hand, the pedestrian access to the stations was neglected, especially at the terminals, which increased the travel times for passengers to reach to the platforms through long ramps without at-grade crossing (Ernst, 2005). These findings reveal that car-oriented habits are embedded in planning and do not consider the experience of pedestrians and cyclists during the design process.

4.4 Managing of competing transport modes

Bus operators also embodied key stakeholders for the phasing in of the system, especially the ones that already provided bus service along the routes taken over by Transjakarta. In order to prevent disapproval from them, private operators were invited to visit the successful case of the Si99 BRT private operator from Bogotá's Transmilenio for a rapid transfer of knowledge and reduce mistrust (Ernst, 2005). This contributed to gain their support and reduce protest threats. Today, BLU Transjakarta manages the bus operation run by bus companies and some of these were already existing operators with routes that overlapped with the Transjakarta corridors. Their companies were transformed into consortiums through direct negotiations with Transjakarta. Other operators were selected from competitive tendering processes (Angelina et al., 2017; Ernst & Young LLP, 2015). The fleet is purchased and owned by the operators, who make profit through a *buy the service* system, in which they are paid per kilometre travelled throughout their operating contract period, as long as they fulfil the standard level of service required by Transjakarta (Angelina et al., 2017). In this way, the financial and revenue risks are assumed by the government (Ernst & Young LLP, 2015).

During the first year of operations, existing private operators were also contracted to provide integrated feeder services to the trunk lines through paper ticketing. However, this effort failed because operators, who need to rent their vehicles on a daily basis, refused to accept printed tickets as payment options due to the fears of counterfeiting (Ernst, 2005). Before the implementation of the *buy the service* system, drivers were paid per passenger, which led to competition between drivers to haul passengers, delays because they used to wait for the buses to fill and dangerous speeds to get to the stops. With the new system, a safer service is provided, and operators receive salaries without competing for passengers, while gaining access to the BRT segregated corridors (Saraswati & Ramadhan, 2020).

4.5 Financing

4.5.1 Mobilisation of the high upfront investment

In comparison to other mass transit systems, such as MRT and LRT, BRT systems are relatively more affordable by emerging economies. The total capital cost was 1.4 million USD per kilometre and was estimated as the lowest capital cost in comparison to other cities with BRT systems (Hidalgo & Carrigan, 2010). From the total cost of the first corridor, 5.5 million USD were spent for the fleet acquisition. If buses would have been privately provided, the total cost could have been reduced to 500 thousand USD (Ernst, 2005). The construction of the first

corridor in nine months was funded with municipal budget (Angelina et al., 2017). However, the rapid implementation resulted in the underbuilding of road surface, which has led to high maintenance costs and additional construction that were not included as part of the initial investment. Moreover, the procurement of the fleet, stations and fare cards was obtained in some cases without competitive tenders, which has led to its investigation (Ernst, 2005).

A technical review by ITDP showed that Transjakarta would never be self-sufficient with the implementation of the first corridor only and without the removal of the overlapped, conventional bus routes. Consequently, the government of DKI Jakarta aimed to integrate the existing bus operators as part of the system, while continuing with the construction of the rest of the corridors (Angelina et al., 2017). The construction of the following three corridors (corridors 2, 3 and 4) was entirely funded with municipal budget and opened in 2006, while the following corridors (up to corridor 11) were funded as part of the UNEP-GEF project Bus Rapid Transit and Pedestrian Improvements in Jakarta between 2006 and 2012 with municipal budget, in-kind financial contribution from ITDP, and mobilised co-financing from UNEP-GEF. The corridor 12 opened in January 2013. The total investment cost was 640 million USD (Sayeg, 2015).

4.5.2 Revenue sources and maintenance of the system

Transjakarta obtains funds from the operations revenue and provincial subsidy to keep fares affordable. In 2008, the amount of fare subsidy accounted for almost forty per cent of the actual costs (Angelina et al., 2017). In 2011, the subsidy for the system was estimated at 333 billion IDR (23 million USD) (Ernst & Young LLP, 2015). Transjakarta has no financial control for the infrastructure costs, as the construction and maintenance costs are funded by the Jakarta Agency of Public Works, while the maintenance of the fleet is responsibility of the bus companies. However, as the corridors have expanded, the maintenance, labour and operational costs have increased significantly, which may eventually lead to the increase of the amount of subsidies in order to maintain fares affordable (Angelina et al., 2017).

According to rough demand estimates, the first corridor was projected to capture 42,500 daily passengers. The passenger demand after the first six months of operations averaged 49,000 passengers per day. These levels of use generate an approximate daily revenue of 13,000 USD, while estimated daily operations costs were around 8,900 USD, considering bus operations only and excluding ticketing and security costs (Ernst, 2005). The operation of Transjakarta remained at a deficit of 33.4 per cent after four years of operations and the payback time is about six years, which is lower than other BRT systems. In 2017, the subsidy made up for fourteen per cent of the cost per passenger (Angelina et al., 2017). The revenue from operations in 2019 accounted for 672,148,292,788 IDR (46,388,645 USD) (BPS-Statistics, 2020).

4.5.3 Affordability of the system

As Transjakarta is subsidised by the city government, the flat-rate fare started with 2,500 IDR (0.30 USD) and a discounted rate of 1,500 IDR (0.17 USD) for trips between five and six in the morning (Ernst, 2005). The fare rate has been able to hold steady and today it has a cost of 3,500 IDR (0.25 USD, current value) (Kusumaningkatma & Xie, 2020). This flat fare is one of the cheapest BRT systems in the world (Ernst, 2005) and attracts mainly long-distance passengers, who do not need to pay per kilometre travelled, while short-distance passengers can choose a faster mode such as paratransit services (Angelina et al., 2017).

4.6 Design of BRT components

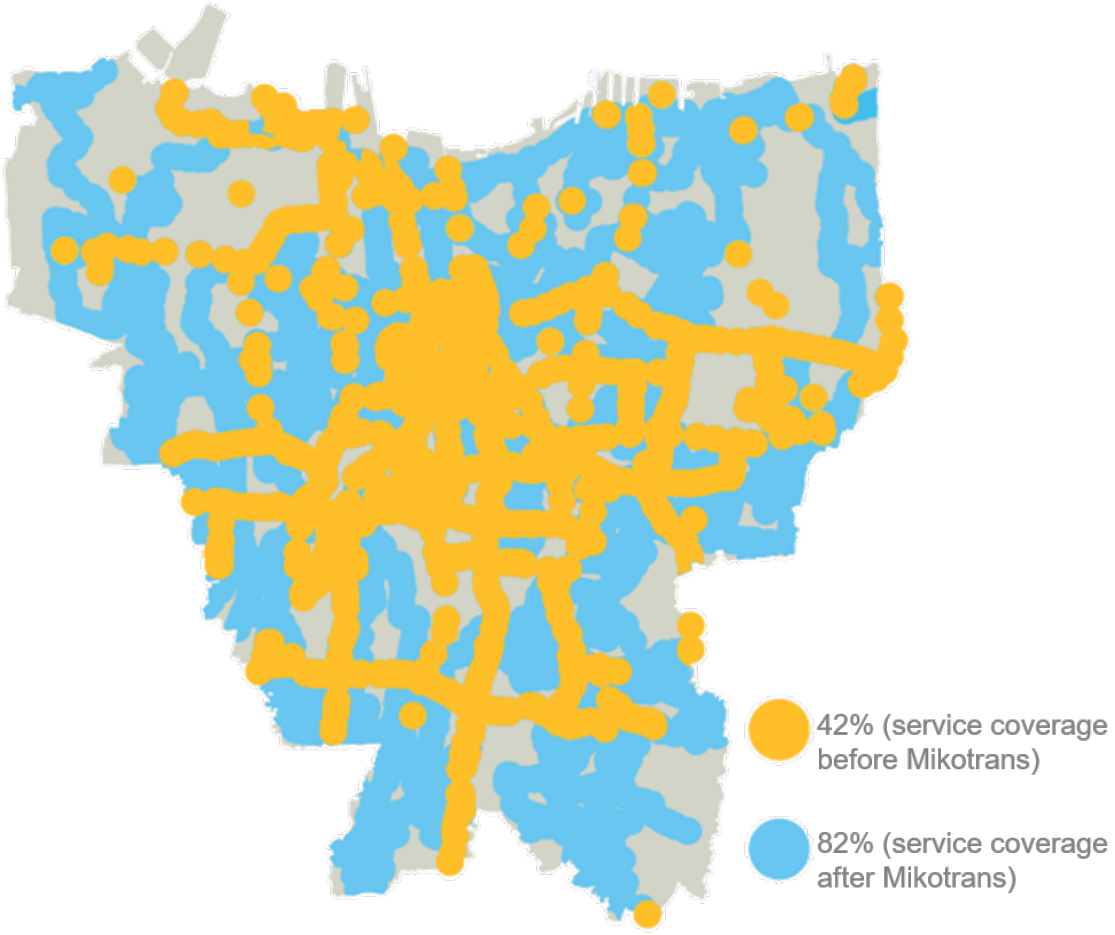
Jakarta has implemented the largest BRT system in the world, with thirteen corridors totalling 251.2 kilometres (Fitriani, Kharisma, Sampurna, Sholihah, & Susanti, 2019) and twenty-two routes that serve eighty-two per cent of the population of Jakarta within 500-metre radius (Adiwinarto, 2020). The system has evolved to provide a better service to the passengers. For example, the initial system had closed corridors only, which meant that passengers could not switch from one corridor to another without leaving the system and paying a new fee (Saraswati & Ramadhan, 2020). On the other hand, the design of the terminal stations lacked efficiency as it underestimated the capacity, producing agglomerations of passengers when alighting (Ernst, 2005). The system complies with typical physical BRT components, such as segregated busways, rapid boarding and alighting, clean and comfortable stations and terminals, and efficient off-vehicle, pre-board fare collection (Ernst, 2005). In addition, Transjakarta complies with also real-time information displays and a great customer service. However, additional features, such as effective licensing and regulatory regimes, intermodal integration and clean bus technologies were still missing during the implementation stage of the system (Ernst, 2005). According to the ITDP BRT ranking (2016), the first corridor Kota–Blok M receives a score of 71 out of 100 and is certified as a Bronze system within the hierarchy of international best practices.

4.6.1 Types of routes

The fleet is compounded by buses with a length of twelve metres with a single wide platform-level door on each side, which also difficulties passenger loading and alighting. The initial fleet consisted of fifty-six buses in operation (Ernst, 2005). However, this has changed in the recent years as the fleet has diversified according to different services and routes. In 2007, the system operated on a closed network with seven corridors, but in 2013, direct service routes were launched to expand the network beyond BRT trunk routes. The network continued expanding in the following years and in 2016, feeder services were also launched (Adiwinarto, 2020).

However, the biggest step in the expansion process was the establishment of the Jak Lingko integrated fare system in 2018 (ITDP, 2021). The system, originally named Ok-Otrip, started as a pilot for the incorporation of universal ticketing for paratransit service into the institutional Transjakarta network system. This pilot gathered regional leaders, paratransit operators and the government in an effort to achieve the integration of Transjakarta with paratransit services, which operators signed a multi-year contract with Transjakarta to provide a service that met the required standards of institutional transit (ITDP, 2021). The formalised paratransit service, with a passenger capacity of eleven passengers, is called Mikrotrans and operates through the Jak Lingko scheme, in which users can combine their trips for a three-hour period using non-cash payment (ITDP, 2021). This ticket costs 3,500 IDR (0.25 USD, current value) (Adiwinarto, 2020; Bank Mandiri, 2022). Mikrotrans has allowed Transjakarta to expand its network over high-density, peripheral areas that, due to the characteristics of the streets, modes of larger passenger capacity could not reach. As a result, Transjakarta serves seventy-two per cent of DKI Jakarta's area, which equivalents 474.9 km2 (Adiwinarto, 2020). Before Mikrotrans, Transjakarta served forty-two per cent of the population of Jakarta, while after the implementation, the service coverage increased to eighty-two per cent of the population, as Figure 1 shows (ITDP, 2021).

Figure 1: Map of Transjakarta with the service coverage before and after Mikrotrans



Source: ITDP (2021)

The investment in the expansion of the network has resulted in the increase of the total numbers of routes by 850% between 2015 and 2020 (ITDP, 2021), which shows the evolution of Transjakarta in recent years in comparison to the phasing-in stage. Table 2 shows the amount of routes of Transjakarta, which gives a total of 248 routes (ITDP, 2022) and are operated by twenty-two operators (seven large bus, four medium bus and eleven minibus operators) (Sufa, 2022). These routes include border routes, which provide service that extends beyond DKI Jakarta borders and reaches the neighbouring provinces of Depok, Tangerang and Bekasi from Great Jakarta, low-entry buses that connect to the trunk lines and are adapted for alighting of passengers at sidewalk level, city tour routes and public housing services (Adiwinarto, 2020). As of 2020, Transjakarta had 248 BRT stations and additional 5,932 bus stops (ITDP, 2022). Consequently, Transjakarta's fleet has also expanded with the diversification of routes and services (Table 3) and today is the largest one in the country (Adiatma, 2020; Sufa, 2020). From the total amount of 3,424 vehicles, only twenty-four per cent are owned by Transjakarta, while seventy-six per cent are owned by the private operators (Adiwinarto, 2020). Most of Transjakarta's owned fleet are articulated buses and single buses from the trunk routes, while the entire fleet of Mikrotrans service is owned by private operators (ITDP, 2022). The new fleet has new additional features to improve passenger comfort and security, such as air conditioner, CCTV and GPS (Adiwinarto, 2020).

Table 2: Total amount of Transjakarta routes in 2020

Route	Amount (%)
Direct service	69 (27.8%)
Mikrotrans	69 (27.8%)
Trunk BRT	55 (22.2%)
Affordable housing	21 (8.5%)
Border routes	14 (5.6%)
Royal trans	13 (5.2%)
Tourism	7 (2.8%)
Total	248 (100%)

Source: Author based on ITDP (2022)

Table 3: Transjakarta fleet in 2020

Route	Amount (%)
Mikrotrans	2,063 (60.3%)
Single bus	718 (21.0%)
Medium bus	240 (7.0%)
Articulated bus	114 (3.3%)
Maxibus	114 (3.3%)
Low entry bus	110 (3.2%)
Other	65 (1.9%)
Total	3,424 (100%)

Source: Author based on Sufa (2022)

4.6.2 Integration with other transit modes

In order to compete with the flexibility and convenience features of private vehicles, transit should be able to let the user navigate in the easiest and most comfortable way possible between transfers, without long distances and waiting times between different systems (e.g. metro and bus). Transfer facilities should count with infrastructure that protects passengers from the environment (rain, very warm or cold weather), but also provides a safer space without robbery or harassment threats. Some Transjakarta stations were poorly designed without considering the connection with key transfer points, such as a commuter rail station (Ernst, 2005). This creates additional unnecessary walking trips that can result unpleasant to the user. On the other hand, the introduction of Mikrotrans as part of Transjakarta has contributed to expand the coverage area of the network and has allowed the fare integration, which goes beyond the physical integration between modes (Saraswati & Ramadhan, 2020).

Jak Lingko has also contributed to the integration of Transjakarta with other institutional mass transit modes, such as the MRT, LRT and the KRL commuter line. In 20202, Jak Lingko expanded beyond a fare integration service through the building of four stations that facilitated the intermodal passenger transfer. Five additional stations were also integrated in 2021. Apart from passenger transfer, these stations have improved pedestrian access with escalators and elevators, as well

as the urban environment through new community and commercial spaces around the stations (ITDP, 2021). The final goal of Jak Lingko is the integration of all transit service providers under a single institution for a better mode sharing and service coverage. This platform also aims to provide a Mobility as a Service (MaaS) solution for intermodal trip planning through a national electronic payment provider in 2022 (Hill, 2021), which can result in the integration of taxi services. One additional co-benefit of Jak Lingko is that, as it is a co-branding collaboration between Transjakarta and the Indonesian Bank Mandiri, the e-Money card can also function as a non-cash payment tool for toll and parking payments, gas stations, retail stores and restaurants with the e-Money logo (Bank Mandiri, 2022). The use of transport cards as non-cash payment contributes to make users' experience more comfortable and attractive beyond transit use.

The new intermodal integration system has also included the improvement of wayfinding systems for a better standardised signage design at bus stops and intermodal hubs. This also improves the image promotion of the system, making it easier to read and more user-friendly. There have also been plans to integrate a citywide bike-share system with Transjakarta (Saraswati & Ramadhan, 2020) through an alignment process between different agencies. In addition to the bike-sharing scheme, there have been improvements of pedestrian infrastructure for better pedestrian connectivity around stations. In 2019, forty-one kilometres of sidewalks within a 400-metre radius of Transjakarta stations were improved, which has led to increase passenger traffic and improve transfer between modes (ITDP, 2021).

5 Transjakarta within the urban mobility system

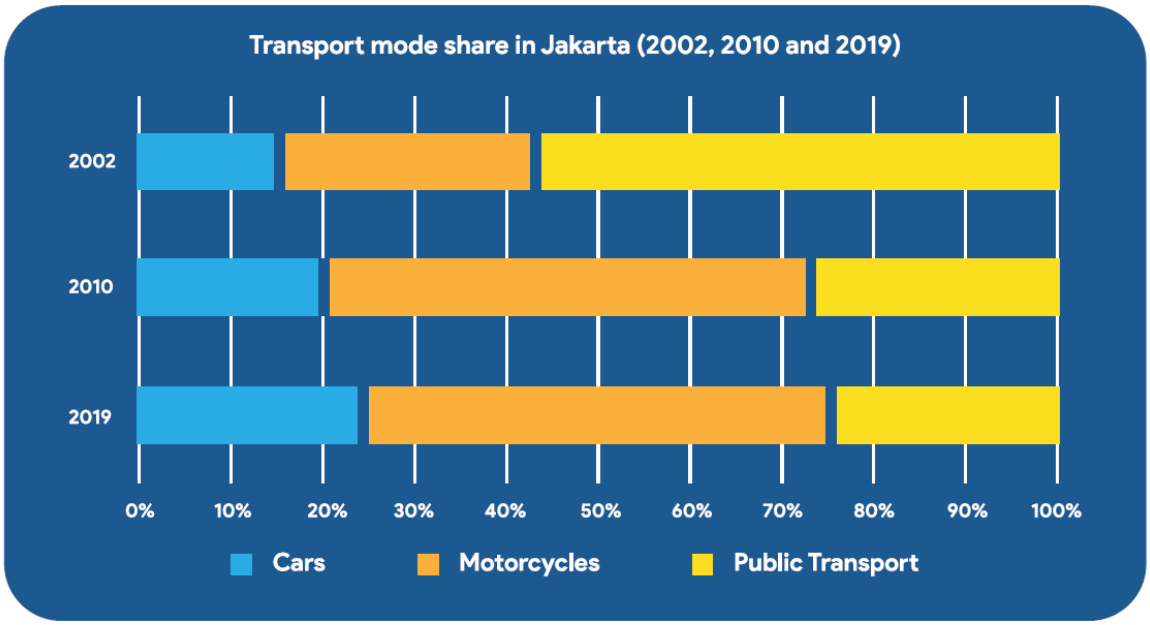
The performance of the system has evolved throughout the years. Between 2006 and 2012, the amount of daily passengers increased from 105,000 to 370,000 passengers per day. However, when analysing the patronage of passengers per kilometre, the figures in fact decreased from 2,500 passengers per kilometre to 2,060 passengers per kilometre, which reveals a declined of productivity by eighteen per cent (Sayeg, 2015). Nevertheless, the expansion of the network and the introduction of Jak Lingko have influenced ridership levels in recent years. In 2019, Transjakarta transported 264,032,780 passengers and showed an increased in the productivity with 2,880 daily passengers per kilometre. The first corridor Kota–Blok M remains as the most transited route with 28,703,262 annual passengers and 6,096 daily passengers per kilometre (BPS-Statistics, 2020). Ridership has doubled in the last two years (Saraswati & Ramadhan, 2020) and the system reached one million daily passengers in 2020 (ITDP, 2021). This is due to the diversification of routes and the integration of the trunk lines with cross, suburban and feeder routes that have increased the passenger demand (Angelina et al., 2017). The stations that were redesigned into intermodal hubs have also benefited from the ridership in other transport modes. For example, the CSW station receives 100 thousand passengers a day from MRT service, while 90 thousand and 25 thousand daily passengers use Transjakarta's corridors 1 and 13 (ITDP, 2021).

At a very low average commercial speed of fifteen kilometres per hour (Angelina et al., 2017), Transjakarta transports around 4,000 passengers phpdt within rush hour (Muhtadi, Mochtar, & Widyastuti, 2017). Regarding the profile of Transjakarta users, a survey from the World Bank at the beginning of operations revealed that sixty-seven per cent of passengers were already former commuters that travelled along the same routes before the opening of the system, fourteen per cent shifted away from their cars, six per cent were motorcycle users, five per cent were taxi users, and six per cent were pedestrians (Angelina et al., 2017). This evidenced that most of Transjakarta users were already transit users and the desired modal shift from private vehicles was not achieved. In the following years, between 2007 and 2012, the implementation of the twelve corridors contributed to an average modal shift of 9.33 per cent of car users and 21.73 per cent of motorcycle users in favour of Transjakarta (Ernst & Young LLP, 2015). One of the

mains reasons why the modal shift has not increased is because the travel time benefit is not attractive enough to attract private modes users (Angelina et al., 2017; Ernst & Young LLP, 2015).

Furthermore, the share of private cars and motorcycles has increased from fifteen and twenty-eight per cent in 2002 to twenty-four and fifty-one per cent in 2019, respectively, whereas the share of transit (including all modes) has decreased from fifty-seven to twenty-one per cent for the same years (see Figure 2) (Adiatma, 2020). This has resulted in the increase of traffic congestion with still ongoing growth of motorisation levels. It is estimated that seventy-five per cent of households own at least one motorcycle, while twenty-five per cent own at least one car (Angelina et al., 2017). In 2019, 61.21 and 23.70 per cent of registered vehicles were motorcycles and private cars, respectively, while buses represented only 2.49 per cent of the motorised vehicles. Moreover, there are 776 motorcycles and 267 cars per 1000 people (BPS-Statistics, 2020). These figures do not consider the number of cars and motorcycles outside DKI Jakarta, but commute on a daily basis from the other areas of Greater Jakarta.

Figure 2: Evolution of the modal split in Jakarta (2002-2019)



Source: Adiatma (2020)

It needs to be mentioned that the increase of fuel subsidy in 2011 and 2012, which counted up to 4.1 per cent of the country's GDP, has contributed to the growth of private mobility, as it not only benefits low-income households, but also middle- and upper-income households. In addition, policy to control private vehicle ownership is missing and, in contrast, the low-cost green car policy of 2013 contributed to make car ownership a more attractive option in comparison to BRT trips (Angelina et al., 2017). As well, the unfamiliarity with new transit technologies can lead to hesitation in favour of the dominant travel mode, while the design failure of the system that produces agglomerations at the stations during peak hours produces discontent among potential users and poor passenger perception, as they link the service to inconvenience, criminality and sexual harassment (Angelina et al., 2017).

However, there have been efforts in the recent years to shift Jakarta from a congested, car-oriented city to a transit-oriented one that gives priority to mass transit and active transport. Once again, a top-down approach, such as the Governor Sutiyoso's has been essential to achieve this new vision of a city. DKI Jakarta Governor Anies Rasyid Baswedan has pushed in favour of improving air quality in the city through the Governor's Instruction No. 66/2019 on Air Quality. As a result, the Jakarta Transport Agency is now responsible for curbing demand for

driving and adopting low-emission transit vehicles (ITDP, 2021). Unlike Sutiyoso, who only focused on the implementation of Transjakarta, the current governor has a more transit-oriented vision that includes all transit modes. This was translated with the increase of institutional transit coverage by 400% between 2015 and 2019 with the introduction of Jak Lingko and the MRT and LRT lines (ITDP, 2021). It is expected that this new vision will change the citizens' behaviour and achieve the shift from private cars and motorcycles to transit use and active transport. Updated mobility studies are required to verify if these new transit-oriented strategies have been successful to reduce pollution and have influenced the modal split in favour of transit use and active transport. What it can be said is that, according to the TomTom traffic index, Jakarta has dropped from the fourth most congested city in the world in 2017 to the tenth place in 2019. In 2021, the city dropped to number forty-six (Baswedan, 2022; TomTom, 2022). This shows positive outcomes from this new approach, but it is also necessary to check if these figures are also the result of the Covid-19 pandemic that has had an impact on the urban mobility worldwide.

6 Co-benefits of Transjakarta

6.1 Reduction of carbon and emissions

GHG emissions from transport sector in Jakarta account for forty-five per cent of the city's emissions. Transjakarta could reduce travel times in ten minutes per passenger trips, and the system has contributed to an annual reduction of 0.15 ton of GHG emissions per passenger in 2012 (Angelina et al., 2017). The shift of passengers from private vehicles to BRT also reduced particulate matter (PM2.5) and nitrogen oxides (NOx) emissions from thirty-one to 1.1 kilogrammes per day and from 232 to twenty kilogrammes per day, respectively, during the first year of operations (Ernst, 2005). Nevertheless, the fleet still contributes to pollution. In fact, in 2018, urban buses in Jakarta contributed to 45.7 per cent of CO2 emissions and 21.4 per cent of air pollutant emissions within the transport sector, which represents the highest figures among all available transport modes (ITDP, 2022). This is because more than seventy per cent the buses are Euro II and Euro III diesel technologies. These buses still emit PM2.5, NOx and black carbon (soot), among other pollutants that affect public health. An study by the International Council on Clean Transportation (ICCT) estimated that 13.5 per cent of premature deaths resulting from air pollution in Jakarta in 2015 were attributable to transport (Kusumaningkatma & Xie, 2020). More updated studies are needed to verify the current impact of the current fleet.

6.2 Industrial development and technological learning

Transjakarta offers opportunities for technological learning to improve the service through complementary technology, such as a GPS-driven control systems to identify key indicators (congestion, peak hours, delays, etc.) in real time and improve operation efficiency and reduce travel times (Ernst & Young LLP, 2015). The integration of the fare system through automated ticketing systems also required technological capabilities to ensure reliability among users (Angelina et al., 2017).

Buses are the most representative vehicles in transit system on a global scale, and most of the fleet are powered by diesel or compressed natural gas (CNG). It is no surprise then that the electrification of transport has become an opportunity to reduce GHG emissions and local air pollutants. Transjakarta offers the opportunity to electrify the fleet and has the potential for industrial development and technological learning within the country. There are already some national documents in favour of the penetration of electric vehicles (EVs) in Indonesia, but with a major emphasis on cars and motorcycles. The MoI has drafted a roadmap in 2020 for the production of low-carbon emission vehicles (LCEVs), including battery electric vehicles (BEVs),

plug-in hybrid electric vehicle (PHEVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs). In 2018, the MEMR planned to stop selling conventional vehicles by 2040, the Presidential Regulation 55/2019 supports EV development and market diffusion in the country (Adiatma & Marciano, 2020). On a city level, Jakarta Governor Regulation No. 03/2020 intends to encourage EV development and adoption (Kusumaningkatma & Xie, 2020). However, even if EVs can reduce GHG emissions and other air pollutants, they would not solve the congestion problem that Jakarta faces. Congestion leads to great economic loss of 1.5 billion USD per year and it was expected to raise up to 7.3 billion USD by 2020 if there are no changes of the transportation system (Angelina et al., 2017).

6.3 Electrification of the fleet

There is a current ITDP project for the electrification of transport in Indonesia, which includes different funding sources, such as the Transformative Urban Mobility Initiative (TUMI), UNEP-CTCN and UK Pact, for the electrification of Transjakarta (ITDP, 2022). The progressive electrification process aims to achieve fifty per cent of the fleet electrified by 2025 (ITDP, 2022) and the total fleet by 2030 (Sufa, 2022). In this way, Transjakarta has already started taking steps towards the electrification of its fleet. In 2019, it initiated a pre-trial of e-buses in partnership with the Chinese manufacturer Build Your Dreams (BYD) and a domestic bus company named Mobil Anak Bangsa. A three-month trial followed, but without its opening to the public because the e-buses could not get the necessary permits for circulation. In 2020, MoT authorised the operation of e-buses in the country and two BYD buses with a length of six-metres and nine-metres each were allowed to circulate as part of Transjakarta service (Kusumaningkatma & Xie, 2020). Moreover, Transjakarta performed pilot tests for the procurement of 100 e-buses by the end of 2020. The company also intends to procure two thousand e-buses on an annual basis (Sufa, 2020). A study carried out by Grütter Consulting on two corridors revealed that the total cost of ownership (TCO) of an e-bus fleet is thirty to 110 per cent higher than the TCO of a standard diesel bus fleet, depending on the selected charging type. If the buses were fast-charged at both ends of their line, the cost of the system would reduce significantly because of the size of the required battery capacity. Without considering the charging infrastructure cost, the TCO of an e-bus fleet could match an internal combustion engine (ICE) bus fleet. The electrification of both corridors served by 137 buses would require an investment of 102 million USD (Adiatma, 2020). The procurement of the first 100 e-buses of Transjakarta's full-fleet transition is receiving the support of C40 Cities Finance Facility (CFF, 2020).

One particular step towards the electrification of the fleet is the electrification of Mikrotrans, which is a completely different approach compared to other cities due to the passenger capacity of these microbuses. This is a significant progress due to the size of the fleet of Mikrotrans (sixty per cent of Transjakarta vehicles) and its service coverage, but it also represents significant challenges, as there are no previous referents from cities with electrified microbus fleets (Sufa, 2022).

There are still some remaining challenges for the electrification of the fleet, from the high upfront cost for the purchase of the vehicles, to the lack of active e-bus suppliers in the Indonesian market. ICCT and the Jakarta-based NGO Leaded Gasoline Removal Committee conducted three fleet electrification workshops in 2020 with representatives from the ministries and city government officials, the utility company PLN and e-bus suppliers. From the workshops, some policy proposals emerged, such as the planning of secondary regulations based on the Presidential Decree No. 55/2019 to lay out a roadmap for national motor vehicle industry development and domestic production of EVs, incentive schemes for domestically produced buses, and the diversion of state budget funds for diesel in favour of electricity subsidies for charging (Kusumaningkatma & Xie, 2020).

6.4 Impact on property prices

Transjakarta corridors have had an additional effect on land values around the stations, with an increase between twenty and thirty per cent in the value of the land in comparison with other neighbourhoods without BRT stations (Rusadhi, 2019). Nevertheless, the lack of integration between transit and land-use planning missed the transformative potential of the system to shape the city. The political pressure to construct the system in a quick and affordable way neglected the opportunity to create active areas to promote the use of non-motorised transport around the stations (Cervero & Dai, 2014; Ernst, 2005). The implementation of TOD strategies during the phasing in the BRT system would have produced greater premiums in areas located around the stations for LVC and property development, while promoting densification nodes in favour of a more compact development to reduce long trips and the sprawling of the metropolitan area. The current TOD strategies adopted by Transjakarta, in combination of TODs applied around MRT stations represent potential opportunities for Jakarta. More studies are needed to verify the success of this new transit-oriented approach.

7 Conclusions and recommendations

Transjakarta is an example of a progressive implementation approach, from the initial phasing-in of trunk lines, to the expansion of the system through the integration of microbuses as feeders and the multimodal integration with other transit modes. Its phasing-in within the consolidated urban area of DKI Jakarta can be assessed based on its success and failure. Transjakarta is the success story of a vision of an innovative system set by the Governor Sutiyoso, in a moment in which public transport was poorly seen by local citizens. His role to carry out with the construction of the first corridor was essential and it is an example of the importance of political will when implementing new transit systems. Nevertheless, his top-down approach resulted in the lack of interest to continue with Transjakarta once Sutiyoso finished his period and other mass transit modes (MRT and LRT) received top priority. As it can be seen in other emerging economies, this evidences the lack of a holistic urban mobility plan for the city, but rather the implementation of isolated projects that are usually linked to a single politician. This is shown when designing stations that are not integrated with other transport modes despite its proximity, which makes it more difficult for the transit user to switch from one system to another through unnecessarily long walking trips.

Transjakarta received the support of UNEP and ITDP, which also evidenced the importance of cooperation with international agencies. Nevertheless, the successful management of private bus operators deserves recognition, as these are key stakeholders for the successful implementation of the system and to have them by their side prevented from rejection to the project. Their visit to the private operators company Si99 in Bogotá can be seen as a good example for stakeholder management and convince them to join the project, instead of the simple removal of paratransit operators. This is particularly significant because the paratransit sector provides jobs to a numerous amount of citizens on a daily basis, and existing bus operators also represent the main opposition when phasing-in institutional transit solutions, especially when they are powerful and have contact with relevant politicians who can block transit projects.

Transjakarta has also been able to face the challenges that other BRT systems have struggled to improve their performance and facilitate the expansion of the network. In recent years, a different and more holistic top-down approach has been applied by Governor Anies Rasyid Baswedan to shift Jakarta towards a transit-oriented city with the integration of all transit modes and correct the mistakes and missed opportunities during the phasing-in stage. In this way, Transjakarta is doing efforts to improve its service and expand its coverage through the

formalisation and integration of Mikrotrans as feeder routes with integrated ticketing. The introduction of Jak Lingko has been essential to expand the network to benefit transit users. In fact, the flat-rate fare of 0.25 USD is one of the cheapest fares for multimodal travel worldwide, which makes the system affordable and accessible for long-distance trips. It will be necessary to see if the recognisable efforts to integrate Transjakarta with MRT and LRT are representing a competitive alternative to private mobility. It is important to mention that, apart from the border routes that represent 5.6 per cent of the routes, Transjakarta does not reach Greater Jakarta, but are rather embedded within DKI Jakarta only. This means that commuters must choose between other transit alternatives or private mobility to get to the city and this is why it is necessary to make the transit user's experience as pleasant and flexible as possible to reduce the high motorising levels of the city.

Today, there are 776 motorcycles and 267 cars per 1000 people, figures that are proper of congested Asian cities, and these numbers do not consider the car ownership levels outside DKI Jakarta that commute on a daily basis. This is translated in the reduction of daily motorised trips carried out in transit modes, which account to only twenty-one per cent in contrast to twenty-four and fifty-one per cent from cars and motorcycles, respectively. Although the efforts of Transjakarta to improve its system and reach its stations to as many households as possible, other government policies are needed. Among these, fuel subsidy on private vehicles should be considerably reduced. As well, more restrictions for cars and motorcycles should be applied, such as road pricing, the implementation of low-emission zones, removal of free parking, more flexible working hours, among others. These measures can lead to change culturally the status symbol of owning a car or a motorcycle and present transit as a more attractive transport mode. At the same time, the expansion of the mass transit network over Greater Jakarta will result significant considering the continuous population growth and the estimations of Greater Jakarta as the largest urban agglomeration in the world by 2030. On the bright side, the current transit-oriented strategies have proven successful to reduce congestion levels, as the city has dropped from the fourth most congested city in the world to the position number forty-six in 2021. This may be a sign of a bright path from a congested city towards a transit-oriented city.

Transjakarta also offers co-benefits in terms of industrial development and technological learning, as the improvement of the system will require technological capabilities for more efficient operation. Furthermore, the EV market also represents a great opportunity for national industrial development, as Transjakarta is planning to electrify its fleet in the following decade. There are currently some policies to promote the manufacturing of electric cars and motorcycles within the country. However, little is being done for the local e-bus industry. On the other hand, the electrification of Mikrotrans will represent an innovative approach for the electrification of small-capacity transit worldwide and Jakarta may become the leader in this branch.

Finally, the lack of integration with land-use planning during the planning of Transjakarta represented a missed opportunity to generate TOD strategies in favour of a more compact development. Furthermore, the lack of additional design strategies around the BRT stations may have reduced the opportunity to increase land values around these areas for property development. Transjakarta is however today adopting TOD strategies, which signifies a promising opportunity for the city. There are other examples of cities that have been able to capture this increased value in favour of financing their mass transit systems. This could represent an innovative alternative for extra funding to keep the fares flat and affordable without compromising the self-sustainability of the system, while improving the urban environment of a metropolis of the size of Jakarta.

References

Abiad, A., Farrin, K., & Hale, C. (2019). Sustaining transit investment in Asia's cities: A beneficiary-funding and land value capture perspective. Metro Manila: ADB (Asian Development Bank).

Acharya, S. R., & Morichi, S. (2007). Motorization and role of mass rapid transit in East Asian megacities. IATSS Research, 31(2), 6-16. doi:10.1016/S0386-1112(14)60217-X

Adiatma, J. C. (2020). A transition towards low carbon transport in Indonesia: A technological perspective. Jakarta: IESR (Institute for Essential Services Reform).

Adiatma, J. C., & Marciano, I. (2020). The role of electric vehicles in decarbonizing Indonesia's road transport sector. Jakarta: IESR (Institute for Essential Services Reform).

Adiwinarto, Y. (2020). Intermodal integration: How Transjakarta improved urban mobility. Retrieved from https://www.itdp.org/event/transjakarta-improved-urban-mobility/

Angelina, S., Vallée, D. H. A., & Louen, C. (2017). The barriers in the implementation process and the operation of innovative urban transport: The case of BRT Jakarta. In S. Ricci & C. A. Brebbia (Eds.), WIT Transactions on The Built Environment: Urban Transport XXIII (Vol. 176, pp. 69-80). Southampton, Boston: WIT Press.

Asimeng, E. T. (2021). Bus rapid transit implementation with the inclusion of incumbent paratransit operators in African cities: Lessons from Accra. Urban, Planning and Transport Research, 9(1), 534-548. doi:10.1080/21650020.2021.2000485

Asimeng, E. T., & Heinrichs, D. (2021). Why do paratransit operators resist participation in bus rapid transit?: Case evidence from Bogota, Mexico City, Johannesburg and Lagos. Transport Reviews, 41(1), 115-135. doi:10.1080/01441647.2020.1818872

Bank Mandiri. (2022). FAQ: E-Money Jak Lingko. Retrieved from https://www.bankmandiri.co.id/en/campaign-e-money-jaklingko%C2%A0

Baswedan, A. (Writer). (2022). Keynote speaker: Anies Baswedan. Governor of DKI Jakarta. In Jakarta e-mobility event day. Indonesia.

BPS-Statistics of DKI Jakarta Province. (2019). Pendapatan per kapita Provinsi DKI Jakarta: Sebuah hasil studi. Jakarta: Author.

BPS-Statistics of DKI Jakarta Province. (2020). DKI Jakarta Province in figures. Jakarta: Author.

BRTData. (2022). Key indicators per region. Retrieved from https://brtdata.org/

Cervero, R., & Dai, D. (2014). BRT TOD: Leveraging transit oriented development with bus rapid transit investments. Transport Policy, 36(November), 127-138. doi:10.1016/j.tranpol.2014.08.001

CFF (C40 Cities Finance Facility). (2020). Zero-emission bus charging systems: Insights from Jakarta. Retrieved from https://www.c40cff.org/knowledge-library/electrifying-bus-routes-insights-from-jakarta

Deng, T., & Nelson, J. D. (2011). Recent developments in Bus Rapid Transit: A review of the literature. Transport Reviews, 1(1), 69-96. doi:10.1080/01441647.2010.492455

Ernst & Young LLP. (2015). Bus rapid transport development in greater Jakarta (Jabodetabek): Finance-ready proposal. India: Author.

Ernst, J. P. (2005). Initiating bus rapid transit in Jakarta, Indonesia. Transportation Research Record, 1903(1), 20-26. doi:10.1177/0361198105190300103

Ernst, J. P., & Sutomo, H. (2010). BRT's Influence on public transport improvements in Indonesian cities. Built Environment, 36(3), 344-352. doi:10.2148/benv.36.3.344

Farda, M., & al-Rasyid Lubis, H. (2018). Transportation system development and challenge in Jakarta Metropolitan Area, Indonesia. International Journal of Sustainable Transportation Technology, 1(2), 42-50. doi:10.31427/IJSTT.2018.1.2.2

Fitriani, S., Kharisma, P., Sampurna, H., Sholihah, S., & Susanti, N. (2019). Sterilization of bus rapid transit special lane case study: Transjakarta. Advances in Transportation and Logistics Research, 2(2019), 473-480. doi:10.25292/ATLR.V2I0.200

Hensher, D. A., & Golob, T. F. (2008). Bus rapid transit systems: A comparative assessment. Transportation, 35(4), 501-518. doi:10.1007/s11116-008-9163-y

Hidalgo, D., & Carrigan, A. (2010). Modernizing public transportation: Lessons learned from major bus improvements in Latin America and Asia. Washington, DC: WRI (World Resources Institute) & EMBARQ.

Hidalgo, D., & Graftieaux, P. (2008). Bus Rapid Transit Systems in Latin America and Asia: Results and difficulties in 11 cities. Transportation Research Record, 2072(1), 77-88. doi:10.3141/2072-09

Hill, A. (2021). Jakarta announces new MaaS scheme. Retrieved from https://www.itsinternational.com/its17/news/jakarta-announces-new-maas-scheme

IEG (Independent Evaluation Group). (2015). Project performance assessment report. Republic of Peru: Lima transport project [IBRD-72090 TF-52877 TF-52856]. Retrieved from https://ieg.worldbankgroup.org/sites/default/files/Data/reports/PPAR.Peru_Lima_Transport_Project.pdf

ITDP (Institute for Transportation and Development Policy). (2016). BRT rankings. Retrieved from https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/best-practices-2013/

ITDP (Institute for Transportation and Development Policy). (2021). Lessons learned from Jakarta's journey to integrated and resilient transport systems. New York, NY: Author.

ITDP (Institute for Transportation and Development Policy). (2022). Transjakarta electric bus system. Retrieved from https://go.itdp.org/download/attachments/179346841/Transjakarta%20E-Bus%20System_Workshop%20E-Bus%20Kampala.pdf?version=1&modificationDate=1647515634812&api=v2&download=true

Jauregui-Fung, F., Kenworthy, J., Almaaroufi, S., Pulido-Castro, N., Pereira, S., & Golda-Pongratz, K. (2019). Anatomy of an Informal Transit City: Mobility Analysis of the Metropolitan Area of Lima. Urban Science, 3(3), 67. doi:10.3390/urbansci3030067

Kumar, A., Zimmerman, S., & Agarwal, O. P. (2012). International experience in bus rapid transit implementation: Synthesis of lessons learned from Lagos, Johannesburg, Jakarta, Delhi, and Ahmedabad. Washington, DC: World Bank.

Kusumaningkatma, M., & Xie, Y. (2020). Transforming Transjakarta: First steps toward electric buses for the world's largest BRT fleet. Retrieved from https://theicct.org/blog/staff/transjakarta-worlds-largest-brt-fleet-oct2020

Lindau, L. A., Hidalgo, D., & de Almeida Lobo, A. (2014). Barriers to planning and implementing bus rapid transit systems. Research in Transportation Economics, 48, 9-15. doi:10.1016/j.retrec.2014.09.026

Mahadevia, D., Joshi, R., & Datey, A. (2013). Low-carbon mobility in India and the challenges of social inclusion: Bus rapid transit (BRT) case studies in India. New Delhi: UNEP Risø Centre on Energy, Climate and Sustainable De-velopment.

Mejía-Dugand, S., Hjelm, O., Baas, L., & Ríos, R. A. (2013). Lessons from the spread of Bus Rapid Transit in Latin America. Journal of Cleaner Production, 50(July), 82-90. Retrieved from 10.1016/j.jclepro.2012.11.028

moovit insights. (2021). Facts and usage statistics about public transit in Jakarta, Indonesia: Commute patterns by Bus in Jakarta – Statistics, Analytics and Usage Data Retrieved from https://moovitapp.com/insights/en/Moovit_Insights_Public_Transit_Index_Indonesia_Jakarta-2044

Muhtadi, A., Mochtar, I., & Widyastuti, H. (2017). Best practice BRT for increase TransJakarta modal share. IPTEK Journal of Proceedings Series, 3. doi:10.12962/j23546026.y2017i6.3254

Muñoz, J. C., & Gschwender, A. (2008). Transantiago: A tale of two cities. Research in Transportation Economics, 22(1), 45-53. doi:10.1016/j.retrec.2008.05.010

Nguyen, M. H., & Pojani, D. (2018). Why do some BRT systems in the Global South fail to perform or expand? In Y. Shiftan & M. Kamargianni (Eds.), Advances in Transport Policy and Planning (Vol. 1, pp. 35-61): Academic Press.

Nurbaiti, A. (2020, October 31). Jakarta wins global 2021 Sustainable Transport Award for integrated public transportation. The Jakarta Post. Retrieved from https://www.thejakartapost.com/news/2020/10/31/jakarta-wins-global-2021-sustainable-transport-award-for-integrated-public-transportation.html

Primatama, M. (2018). Tipping points on transport and behaviour: Examining bus Rapid transit system in Jakarta, Indonesia. Paper presented at the Proceedings of the International Conference of Communication Science Research (ICCSR 2018), Sura-baya, Indonesia.

PT. Transportasi Jakarta. (2016). TENTANG TRANSJAKARTA / SEJARAH Retrieved from https://transjakarta.co.id/tentang-transjakarta/sejarah/

Razvadauskas, F. V. (2018). Megacities: Developing country domination. Retrieved from https://go.euromonitor.com/strategy-briefing-cities-2018-megacities.html?utm_campaign=SC_18_10_02_Megacities&utm_medium=Email&utm_source=1_Outbound

Rodriguez, D. A., & Vergel Tovar, E. (2013). Bus Rapid Transit and urban development in Latin America. Land Lines, 25(1), 14-20. Retrieved from https://www.lincolninst.edu/publications/articles/bus-rapid-transit-urban-development-latin-america

Rusadhi, E. P. (2019). The impact of Transjakarta bus rapid transit on land value of DKI Jakarta province subdistricts. Plano Madani, 8(2), 196-204.

Saraswati, K., & Ramadhan, G. (2020). 15 Years on,Transjakarta is better than ever. Sustainable Transport, 31(January), 23-25. Retrieved from https://www.itdp.org/wp-content/uploads/2020/02/ST31.smnew_.pdf

Sayeg, P. (2015). Post evaluation of a decade of experience with Jakarta's Transjakarta bus rapid transit system. Proceedings Australasian Transport Research Forum. Retrieved from https://trid.trb.org/view/1395108

Sayeg, P., & al-Rasyid Lubis, H. (2014). Terminal Evaluation of the UNEP/GEF Project "Bus Rapid Transit and Pedestrian Improvements Project in Jakarta": UNEP (United Nations Environment Program).

Sufa, F. (2020). Low-to-no emissions journey of TransJakarta BRT system. Retrieved from https://www.ccacoalition.org/en/file/6838/download?token=sUH7MbeD.

Sufa, F. (2022). Developing an e-bus roadmap to scale: Jakarta's study on Mikrotrans electrification. Retrieved from https://www.itdp.org/wp-content/uploads/2022/05/Jakartas-Study-on-Mikrotrans-Electrification_Faela-Sufa.pptx.pdf

Susilo, Y. O., Tjoewono, T. B., Santosa, W., & Parikesit, D. (2007). A reflection of motorization and public transport in Jakarta metropolitan area: Lessons learned and future implications towards better transportation development in developing countries. Journal of the Eastern Asia Society for Transportation Studies, 7, 299-314. doi:10.11175/easts.7.299

TomTom. (2022). Traffic index 2021. Retrieved from https://www.tomtom.com/en_gb/traffic-index/ranking/

Van Cleve, M. (2020). Back to the future: Our world's cities in 1985, and today. Sustainable Transport, 31(January), 26-37. Retrieved from https://www.itdp.org/wp-content/uploads/2020/02/ST31.smnew_.pdf

Wijaya, S. E., & Imran, M. (2019). Transport planning and policies in Indonesia. In S. E. Wijaya & M. Imran (Eds.), Moving the masses: bus-rapid transit (BRT) policies in low income Asian cities: Case studies from Indonesia (pp. 51-73). Singapore: Springer Singapore.

Wu, I., & Pojani, D. (2016). Obstacles to the creation of successful bus rapid transit systems: The case of Bangkok. *Research in Transportation Economics, 60*, 44-53. doi:10.1016/j.retrec.2016.05.001