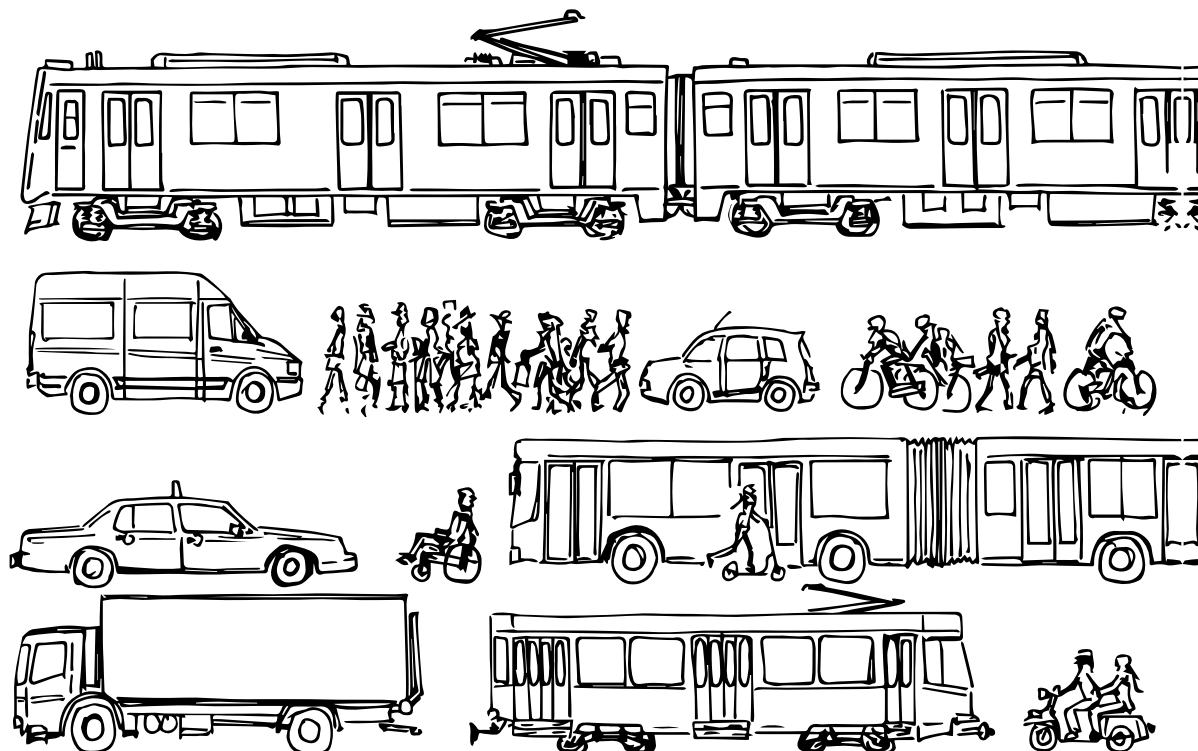




Transforming Urban Mobility in Phnom Penh

**Towards Inclusive
and Equitable
Urban Accessibility**



Research Team

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Phnom Penh, Cambodia

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1. INTRODUCTION

This report aims to provide a first-order quantification of the economic and social costs of organizational and infrastructural deficits that affect the current state of urban mobility in Phnom Penh. Methodologically, the report adopts a broad urban design perspective on which all considerations, economic and beyond, are based. Research and documentation have shown that the assignment and management of urban space is one of the key aspects in understanding, factoring and addressing the current deficits.

A core focus of this study is to understand the opportunity costs of not investing in specific measures that would allow for efficient,

sustainable urban mobility. Similarly, possible impacts of efficient urban mobility on Cambodia economic growth are discussed, Phnom Penh is considered one of its main growth contributors.

The holistic approach that this entails includes, among others, considerations of the use of road space (active lanes), sidewalk space (whether physically delimited or not) and the organization of activities taking place on urban surfaces dedicated to urban mobility. Together with consideration of derived economic and social costs, this allows for identifying systemic issues (chapter 10) and drafting possible outcomes and solutions according to insights found (chapters 11 and 12).



2. OBJECTIVES OF THIS REPORT

2.1. Declared Objectives

The Goal of this Report is to provide a more systemic understanding of urban mobility in Phnom Penh, including the needs and perceptions of local citizens and urban experts. It also aims to provide insights and analysis for urban stakeholders and Phnom Penh policymakers in the 2020-2025 period, allowing them to curtail and shape upcoming policy decisions. The focus of the report, while respecting all requirements of scientific rigor, is thus on clearly carving out key messages in a format intuitive to understand, with a core focus on the costs resulting from the current deficits in Phnom Penh's mobility field.

Given the availability and degree of detail of existing research on topics of urban transport in Phnom Penh, this report has been written to be accessible to readers with no particular expertise in the fields of transport and urbanism:

- The key focus has been set on proposing possible recommendations to advance resolution of complex systemic issues, using a dynamic analysis of mobility related issues and challenges.
- Key messages are derived and outlined in a compact yet precise format.

Based on urban accessibility considerations, this report highlights key trends and drivers shaping both current and future mobility in Phnom Penh. In its methodology, it is largely based on crucial insights that have been distilled from both analytic observations on-site as well as findings derived from a comprehensive interview with experts and stakeholders of Phnom Penh's urban mobility. It is based on a non-technical acknowledgement of existing data augmented by:

- observations in the field collected by the research team, with a focus on those illustrating and highlighting the latest trends not or only partly identified in previous work
- interviews with a broad range of stakeholders of the urban transport system
- a highly specific, supplemental collection of data considering shift in modal use
- a large number of documentary photos and illustrations have been included to support the broad approach that has been chosen.

Most importantly, the report highlights the opportunity costs of not investing in specific measures that would allow for efficient, sustainable urban mobility.

Based on the robust data that the research team accessed, this report draws a “now and then” picture that ultimately leads to an (expectable) cost reduction plan—respectively the cost of doing nothing (non-intervention scenario).

A 2-page summary (chapter 3.2.) based on infographics complements a brief executive summary.

2.2. Methodology

This report lays out a new agenda providing the basics for transforming urban mobility in Phnom Penh. It analyses the role and summarizes the demands of local actors that are part of the ecosystem, from the public to private actors to civil society representatives. Most importantly, it explains what the current mobility situation is, identifying current and future trends including but not limited to road safety (traffic accidents and near misses), air quality, traffic congestion, and transportation safety and overall citizen consumption of and perceptions relating to urban mobility.

The Phnom Penh urban mobility situation has already been analyzed in much detail e.g. in the 2014 JICA reports. What is different about the present work is its focus on the analysis of issues and challenges, and especially the generalized (i.e. social and economic) cost aspect. The report also discusses the impacts of more recent mobility changes and their impacts on urban transport, such as the appearance of ride-hailing and “Tuk Tuk” motor rickshaws that significantly impacted the economics of the transportation market, together with the strongly increasing import of second-hand motor vehicles, mostly passenger cars. Both phenomena are special to Phnom Penh and do not linearly follow the “classic” examples for these market shifts as observable in Asia and Southeast Asia.

Proceeding from this analysis, suggestions and recommendations are derived for possible courses of action that may ultimately pave the way for high-level decision-making concerning infrastructural solutions. Thus, both the infrastructural asset situation as well as the demand side of Phnom Penh’s urban transport markets are discussed, balancing the current supply side presented in the report. Different needs are identified for different

socio-demographic categories, and changing socio-economic household demographics are considered factors to elicit possible impacts of a lack of efficient urban mobility on Phnom Penh’s - and Cambodia’s - growth, Phnom Penh being considered one of the main growth contributor to the country’s economy.

The report uses a social science-based approach combining comprehensive field interviews with urban experts and policymakers, traffic count surveys, and policy analysis. From an analysis of both Phnom Penh’s urban development side (urban form and projected urban evolution) and Phnom Penh’s current transportation system, the report synthesizes conceptual views of how the city grows with the transportation system. Given the extremely rapid shift from pedestrian-dominated to car-dominated mobility over the past 15 years, the management and occupation of urban space needs to be center stage.

The report’s analysis and findings are based on in-depth interviews conducted with stakeholders of the different components of urban mobility in Phnom Penh, on quantitative data received from these stakeholders, and on qualitative findings by the research team.

3. SUMMARY

3.1. Summary and Synopsis of Results

This report takes an **urban design based approach to urban mobility**. It is based on on-site investigations by the research team, on literature review, and on high-level interviews with major stakeholders of Phnom Penh's urban transit system. The starting point is an observation of the influence of the built environment on urban mobility. To obtain a sufficiently complete picture, it is necessary to understand how and to what extent the past evolution and the present state provide a base for possible future development paths. Thus, two crucial factors are highlighted—the evolution of urban land use and the role of green public spaces. While there is an overall lack of urban public green spaces in Phnom Penh, strengthening the implementation of a mixed land-use master plan including more urban public green space appears to be a key element for the promotion of active mobility. A decentralization of the city center is to be investigated with the design of three city zones in Khan Kambol, Khan Chroy Changvar, and Khan Meanchey.

A consideration of the current situations and challenges within the **transport infrastructure** in Phnom Penh addresses the performance of the overall infrastructure that influences current and future actionable areas in urban mobility. The authors find a lack of connectivity in road networks in Phnom Penh due to the low density of streets and intersections, particularly in suburban areas. An improvement of the connectivity of the road infrastructure should include ring roads and bridges crossing rivers. Furthermore, sidewalks should progressively be freed from illegal parking and vending

activities, given their crucial role in encouraging pedestrian movement and fostering non-motorized and proximity mobility, thus promoting social interaction and public health. At least for a transitional period, more official parking spaces are required.

In the field of **public transportation**, the current array of publicly accessible options include both fixed-route systems – road, rail, or waterborne—running large vehicles as well as on-demand systems operating smaller vehicles that can be flexibly dispatched. A brief presentation of the main modes is given in the following sub-chapters together with some compact, critical remarks on their present role within the urban mobility ecosystem, serving as a base for recommendations. It is crucial to note that currently the largest passenger volume is handled by the total of various on-demand modes. The rapid increase in privately owned vehicles, insufficiency of traffic facilities and road carrying capacity combine to cause serious traffic congestion and accidents. More public transport modes have been introduced and expanded: public bus services from 2014, and the airport rail link and water taxi services since 2018.

Re-counts on traffic at 5 different major streets in Phnom Penh showed a significant increase in proportion of Bajajs from 2012 to 2019: as a consequence, the current situation in public transportation is a source of serious challenges related to the efficiency of the use of public road space, of the widespread availability of low-cost public transport services, and ultimately of social equity.

The next chapter focuses on **urban logistics**, including an overall view of urban cargo, street

vendors, waste management, and heavy freight haulage. The report finds that a majority of urban public spaces have been converted to private purpose usage including on-street business activities, resulting in inequities in access to urban resources. The current modus operandi in Phnom Penh basically assigns movements of heavy goods vehicles within the city parameters mainly to night hours for all movements that do not require daytime intervention e.g. for goods reception or processing, loading or unloading. Equilibrating the spatial and temporal use of urban space by switching urban cargo logistics to night times could be a key for solving obstruction and congestion issues in Phnom Penh. Regarding waste management, the system should be improved by delegating the tasks and responsibilities to contracted companies.

A consideration of evolving **socio-economic and environmental conditions** of Phnom Penh links urban mobility to population growth, employment, household income, vehicle ownership, energy consumption and air quality. Related challenges of population growth and travel demand for jobs are also discussed, both of the above having led to a higher demand for urban mobility in Phnom Penh. The number of registered vehicles in the city has increased by 7.4% annually between 2007 and 2017. More than 80% of the vehicles are second-hand imported vehicles, which result in an increase in energy demand and air pollution.

The report further looks into related **road safety relevant issues**, including the current situation, the responses by authorities, and possible actions. In 2004, the Road Crash and Victim Information System (RCVIS) was established to collect more reliable road crash data in Cambodia, and the National Road Safety Committee (NRSC) publishes an annual country summary report about road crashes and casualties.

Results **from interviews with transport system stakeholders** with various professional backgrounds and insights (e.g., government officials, researchers, business owners, and development agencies) have been hierarchically classified and analyzed to identify the urban issues seen as most pressing as well as stakeholders' future consideration regarding challenges and possible solutions. Globally, interviews yield two core takeaways: A functional and political linkage and interdependency exists between high-level interventions into Phnom Penh's urban mobility, which cannot be targeted and handled in an isolated manner, but only jointly in a multi-disciplinary approach. Also, all are perceived as having to be addressed with comparable importance.

Finally, the report investigates **externality costs relevant to urban mobility**. It highlights a set of key transport externalities--elements that carry an important weight--and proposes the calculation of associated external costs which characterize the current urban transport situation in Phnom Penh. From combined observations, measurements, international comparisons and third-party information, the different components that add up to an estimated total yearly cost of urban transportation externalities were also predicted based on certain assumptions. The research team estimates the total cost to Phnom Penh's Economy will be between USD 500 million and USD 700 million per year.

Based on the findings in a **concluding chapter**, a three-phase model is presented based on the overall findings and conclusions from earlier chapters. It suggests benchmarks for policy discussion on how to transform the urban mobility in Phnom Penh into a more inclusive and equitable one.

3.2. Summary of Recommendations

More Green spaces: Pedestrianized streets promote non-motorized transport and strengthen urban equity in access to urban resources. Public green spaces are a key element for the promotion of active mobility.

Road network: Roads in Phnom Penh overall appear not to be well connected due to the low density of streets and intersections, particularly in the suburban areas. An improvement of the connectivity of the road infrastructure needs to integrate ring roads and bridges crossing rivers. The development of ring roads can connect major mobility corridors and help ease traffic congestion in the city center and encourage more development in the peripheral districts of the city.

Walkability: Existing sidewalks are occupied by illegal parking and vending activities. Proper sidewalks encourage pedestrian movement and accommodate the demand for non-motorized transport, thus promoting social interaction and public health.

Parking Spaces: More legal on- and off-street parking spaces are required to accommodate the increasing number of registered vehicles in the city, at least for a transition period until efficient public transit is available. Sidewalks are progressively to be freed from conflicting illegal parking and vending activities.

Privately held Vehicles: A rapid increase in privately owned vehicles faces an insufficiency of traffic infrastructure and facilities and road carrying capacity. This leads to serious traffic congestion and accidents. To reduce CO₂ emissions, policy interventions (e.g., restrictions on importing and tax leveraging for second-hand vehicles) should be considered.

Public Transport: More modes have been introduced and expanded in recent years: public bus services from 2014, ride-hailing services since 2016, and airport rail link and water taxi services since 2018. Re-counts on traffic by the research team at 5 different major streets in Phnom Penh notably showed a significant increase in the proportion of Bajajs from 0% in 2012 to 8.2-11.0% in 2019. Bajajs have taken over a major role in public transport. To reduce both energy demand and air pollution, promotion of fixed-line, high-capacity urban public transport services would be a solution better suited to the city.

Urban Cargo Logistics: Equilibrating the spatial and temporal use of urban space by switching urban cargo logistics to night times could be a key towards solving obstruction and congestion issues in Phnom Penh. Also, a “last mile” delivery system should be reconsidered based on a minimization of the overall number of vehicle trips, finding an equilibrium between heavy and small vehicle trips that is sustainable from both economic and societal aspects. Also, a further revision to the currently poor waste management system that has aggravated the environmental quality in the city is required.

A three stage model of short term, medium term and long term phases has been defined, covering the period from 2020 to 2050. A coordinated set of interventions, developments and investments in the field of urban mobility have then been assigned to the different phases, detailed in chapter 12. These measures include

Urban Cable Cars and Bus Rapid Transit (BRT) as fast-to-implement, short-and medium-term investments that can later be replaced and/or supplemented by heavy rail-based mass transit in a rolling planning. The authors recommend starting with BRT and Urban Cable Cars for quick fixes while system decisions on rail mass transit layout details are being reviewed.

Mass Transit that is to be developed along existing and redefined city axes to act as a major urban development vector. Requiring heavy infrastructural investment, it is to combine an integrated development of commuter rail on existing and revived rail corridors as well as a new grade-separated system such as Metro, Automated Guideway Transit, or Skytrain.

Road Pricing as a measure to control and steer usage of a given road infrastructure that will be limited despite the suggested investments into alterations and expansions. Road Pricing allows for a dynamic steering of demand and supply that can be adapted to the different phases of expansion of road infrastructure, public transit, and policy measures.

Urban Cargo Distribution equilibrated between standardized small containers linked to peripheral urban distribution centers and dynamically optimized trips of selected heavy

vehicles straight to destination. The goal is an economically competitive system that is affordable, sustainable and fast, and complies with urban metrics such as the overall reduction in vehicle trips.

Motorcycles and Private Vehicles should in the future mainly be used to connect to and from rail-based mass transit. Similarly, Bajajs and other private-hire vehicles are to be reassigned mainly to last-mile connection services as part of an intermodal approach to public transport comprising fixed-route as well as on-demand components.

3.3. Representation as Infographic



The infographic on the following pages gives a synoptic overview on approach, process and findings. Source: Research Team.

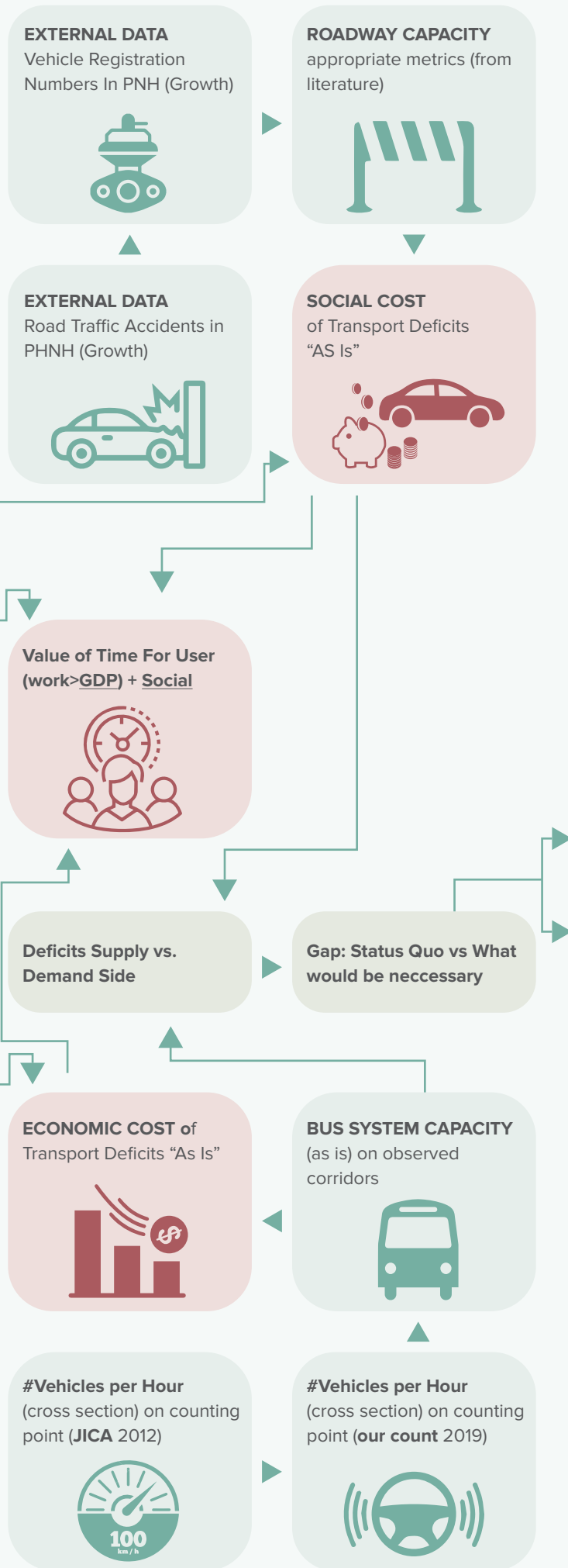
Urban Design based Approach: URBAN STRUCTURE Urban Development Strategies, Patterns and Evolution Scenarios

- 
TRANSPORT INFRASTRUCTURE
 Influencing current and future actionable areas in urban mobility
- 
PUBLIC TRANSPORTATION
 Fixed Route: Road, Rail, Water On-Demand: Small Flexible Vehicles
- 
URBAN LOGISTICS
 Urban Cargo, Waste Management, Street Vendors, Heavy Freight
- 
SOCIO-ECONOMIC AND ENVIRONMENTAL CONDITIONS
 Population Growth, Employment, Household Income, Vehicle Ownership, Energy Consumption, Air Quality
- 
ROAD SAFETY ISSUES
 Current Situation, Response by Authorities, Policy Implementation Experiences

- 
DEMAND INCREASE
 From New **COMMERCIAL** Construction in PNH Centre
- 
DEMAND INCREASE
 From New **RESIDENTIAL** Construction in PNH Suburbia

CORE ANALYTICAL APPROACHES BY RESEARCH TEAM

- 
INTERVIEWS WITH MOBILITY SYSTEM STAKEHOLDERS
 From various backgrounds Most pressing issues / challenges
- 
EXTERNALITY COSTS RELEVANT TO URBAN MOBILITY
 Identification of key externalities and associated external costs



RECOMMENDATIONS Three-Stage Model
Coordinated Sets of Interventions:
=FULLY INTEGRATED APPROACH

MORE GREEN SPACES

- Pedestrianized Street
- Equity in Access
- Active Mobility

ROAD NETWORK ADAPTATIONS

- Focus on Citywide Connectivity
- Ring Roads and Bridges
- Intersection Management

WALKABILITY

- Remove Illegal Parking
- Promote non-motorized transport and boost neighborhood activities

PARKING SPACES

- Provide Legal On- and Off-Street PP
- Accommodate rising vehicle #s
- Clear Sidewalks
- Transitory until Rail Transit Set up

Economic Cost of Non-Intervention

Social Cost of Non-Intervention

PRIVATELY HELD VEHICLES

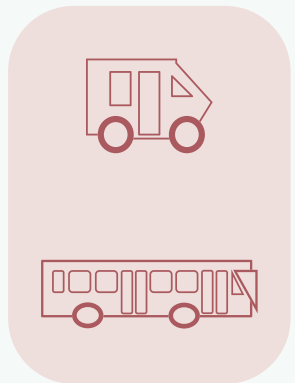
- insufficient infrastructure
- Congestion, Accidents, Emmissions
- Conflicts

PUBLIC TRANSPORT

- Fixed-Routed: Citybus Service, Airport Train, Water Taxi
- On-Demand: Bajajs

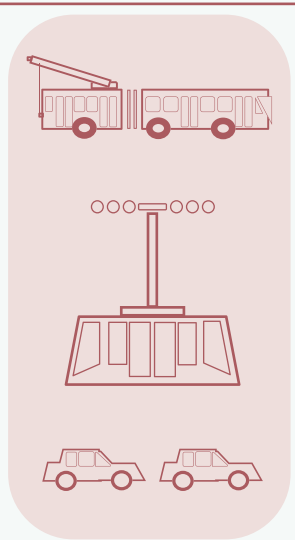
URBAN Logistics

- Last-Mile Delivery System
- Minimizing Vehicle Changes
- Affordability and Management Od Public Space (Loading...)



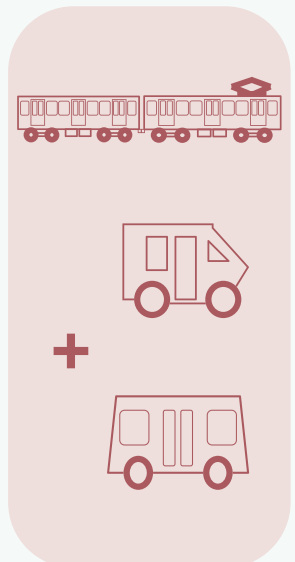
PHASE S: SHORT TERM 2020-2025

- Priority on Mass Transit Planning
- Parking Enforcement
- Walkability and Active Mobility Promotion
- Bus Rights-of-Way, Timetable Stabilization
- Revised Mass Transit Planning to Integrate Land Use Masterplan
- Planning for "Quick Fix" BRT



PHASE M: MEDIUM TERM 2025-2035

- BRT to operate as precursor of rail (Pre-Metro functionality)
- Rail Transit decision being taken
- Classic Rail Corridors Revived
- Rapid setup of Urban Cable Cars to extend across Mekong
- Creating New Transit Corridors bajajs reassigned to Paratransit
- Walkability Standards
- e-bikes replace motorcycles



PHASE L: LONG TERM 2035-2050

- Land development strategy focused on metro + rail network
- Equity in Access through automated Paratransit Service replacing Bajajs
- Dynamic Congestion Charge and phasing out unclean vehicles

=ACTIONABLE ITEMS

4. URBAN STRUCTURES

Summary:

This chapter considers the influence of the built environment on urban mobility. To obtain a sufficiently complete picture, it is necessary to understand how and to what extent the past evolution and the present state provide a base for possible future development paths. Thus, both the evolution of urban land use and the role of green public spaces are briefly highlighted.

4.1. Urban Growth and Land Use

Phnom Penh has grown very fast for the past 20 years. The remarkable new developments are expanding to the west along National Road 4 (NR4), to the south along NR2 and Hun Sen Boulevard, and the north along NR5 and NR6. The expansion to the east is considered difficult due to the presence of major waterways and wetlands.

Figure 4.1. depicts new built-up areas from 1987-2017, and projects likely expansion into 2057. The built-up and bare soil areas increased by 3.1% and 6.6% between 1987 and 2017, respectively. Both built-up and bare soil are projected to grow at 2.5% and 2% annually over the next 40 years (2057). The current and expected developments on the fringes of the city, including suburbanization through both residential and commercial real estate, have the potential to heavily influence transport

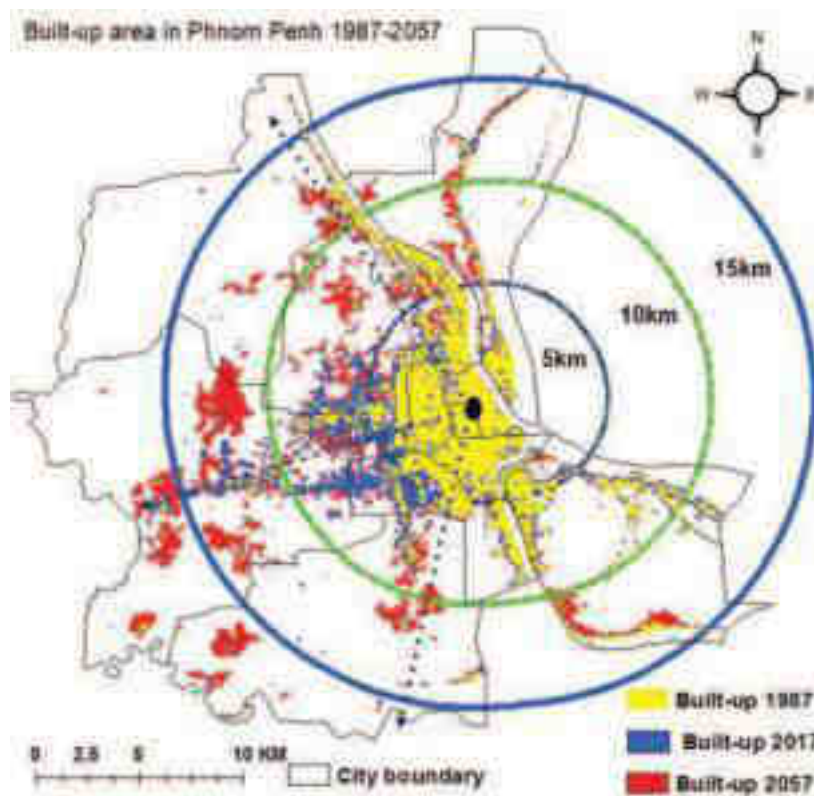


Figure 4.1. Land Use Simulation Model running in Cellular Automata Model (CA) for land-use changes of Phnom Penh between 1987 and 2057 (Research Team, 2020)

movements, resulting in a steep increase of urban mobility demand side, while new arterial roads built ahead of new developments precondition the supply side. Thus, these phenomena are of particular interest for this report.

In contrast, agricultural land decreased sharply by 15.9% from 1987 to 2017 whereas the water body also diminished by 0.7% between 1987 and 2017. Both agricultural and water areas are estimated to fall by 7.6% and 0.2% respectively over the next 40 years. This rapid expansion of urban areas reclaims a large quantity of agricultural, green, and water areas, which result in food insecurity and loss of ecosystem services. Further, the increasing newly urbanized areas will lead to higher travel demand (i.e., urban mobility) if the spatial accessibility to basic urban facilities/ services (e.g., administration, banking, business, commerce, education, and health) is not equitably distributed or is concentrated in the central hubs.

4.2. Public Green Spaces

Green spaces are interlinked with factors such as citizens' location of residence, travel behaviors and social and recreational activities: A good level of accessibility and availability of Green Spaces in the vicinities of citizens' points of presence can, besides its

immediate ecological and “soft” effects such as shading and noise reduction, significantly reduce socially-induced mobility. People who live in cities with a higher density of green spaces tend to walk and bike more often than they use forms of motorized transport (Rojas et al., 2016). Additionally, scholars observe that people prefer living in locations where greenery and accessible infrastructure are close (for a timeless analysis, see e.g. Gehl, 1971). The same basic phenomenologies have been observed for Phnom Penh (City of Phnom Penh, 2009). However, the low density--nay, the near-complete absence--of public green spaces in Phnom Penh forces people to travel a long distance if they wish to visit the handful of green spaces that still remain. In such a case, people will choose the automobile or other motorized vehicle as a mode of travel.

The green spaces in the city are small and mainly serve as public amenities rather than for public recreation. According to the World Health Organisation, every city should have a minimum of 9m² of urban green space for each person. However, Phnom Penh had 87 public spaces (including public green spaces) where 66 of them were located in the central districts with a combined area of 0.67 sq.km, which is less than 1 square meter (m²) per person, comparing



Figure 4.2. Public Green Spaces in Daun Penh District, Aug 2019 (Research Team, 2020)

to 29.2 m² in New York and 5.5m² in Tokyo (Sahmakum Teang Tnaut, 2018a, GGGI, 2019). Another study of more than 500 young adults in the city in 2016 indicated that 94.4% of them expressed a strong demand for public green spaces. However, most of the respondents also mentioned other issues of concern, such as lack of public toilets (84.7%) and rubbish bins (75.6%), long-distance (≥ 5 km) from home (49.6%), and safety concerns (58.7%) (Yen et al., 2016). Figure 4.2. shows the typical example of public green space in Daun Penh District.

Street greenery has long been recognized for its importance in improving environmental, recreational, and aesthetic conditions within urban areas. Nevertheless, Phnom Penh shows a low density of trees, especially in suburban areas. As of 2018, the government registered 42,030 street trees from 382 streets in Phnom Penh. About 50 out of 382 streets have less than 10 trees for each street. This proportion is small, compared to other cities. For example, London has 8,421,000 trees, yielding annual benefits of £132.7 million (not including all services), a replacement cost of £6.12 billion, and an amenity value of £43.3 billion. A square kilometer of tree cover could save an average of USD 83 per city resident annually (Endreny, 2018). This includes the tree cover that saves USD 0.93 million in air pollution and health cost, USD 478,000 in building energy heating, and USD 20,000 in capturing water runoff.

Another study indicates that an entire tree with 12 m height and two tonnes could produce 100 kg of oxygen per year whereas a human needs 740 kg of oxygen per year to breathe. This

means that every human needs roughly eight trees to produce oxygen for them (Crowther, 2018). In the case of Phnom Penh with a population of about 2.2 million in 2019, the city may need more than 17 million of such trees to produce oxygen.

This in itself triggers the question on the linkage of urban green spaces to mobility: Green spaces have been widely proven to have a significant impact on both walkability and the perception of accessibility, actively making public spaces more inclusive (Gehl, 2010) as well as on its perception. Also, very targeted, proactive strategies regarding the deployment and culture of urban green as an integral part of progressive urban transport strategies have been developed from global experiences and condensed into guidelines perfectly adaptable to a Phnom Penh context (see e.g., Speck, 2018).

Despite the efforts of the Royal Government of Cambodia to transform Phnom Penh into a greener city, following the Phnom Penh's Master Plan on Land Use 2035, challenges to preserve natural green spaces from land privatization and the market economy system are leading to increasing depletion of those natural spaces. Many private investors, especially real estate developers, do not enforce green development approaches and do not comply with the legal principles embedded in the law on construction that require every development project to reserve 30% for green spaces. Real estate developers feel constrained if they follow recommended guidelines, citing considerable space losses for development (Cambodian Construction Association, 2019).

Key Takeaways:

- There is a lack of urban public green spaces in Phnom Penh.
- The mixed land-use master plan including more urban public green space to promote active mobility ought to be implemented more forcefully.
- Decentralization of the city center is recommended, with three city zones to be designed in Khan Kambol, Khan Chroy Changvar, and Khan Meanchey.

5. TRANSPORT INFRASTRUCTURES

Summary:

- This chapter explains the current situation and challenges within the transport infrastructure in Phnom Penh. It further addresses the performance of the infrastructure that influences current and future urban mobility.

5.1. Urban Road Networks

An urban road network has been a key achievement in supporting Phnom Penh’s successful city growth and a key factor to support local economic growth. However, the road networks in Phnom Penh remain insufficient as they do not ensure efficient connectivity to suburban areas (e.g. western districts), and increase the travel distance required to access urban facilities/services for people that do not live in “Borey” (gated communities). It was also

found that some road patterns negatively affect the mobility of vehicles. For example, some potential two-way streets that often attract a high traffic volume have been proposed to be changed into one-way streets to improve traffic flows in particularly dense urban areas. Potentially decongesting measures that are being studied by the Phnom Penh Municipality and the Ministry of Public Works and Transport to further turn some street sections into one-way roads are commendable.

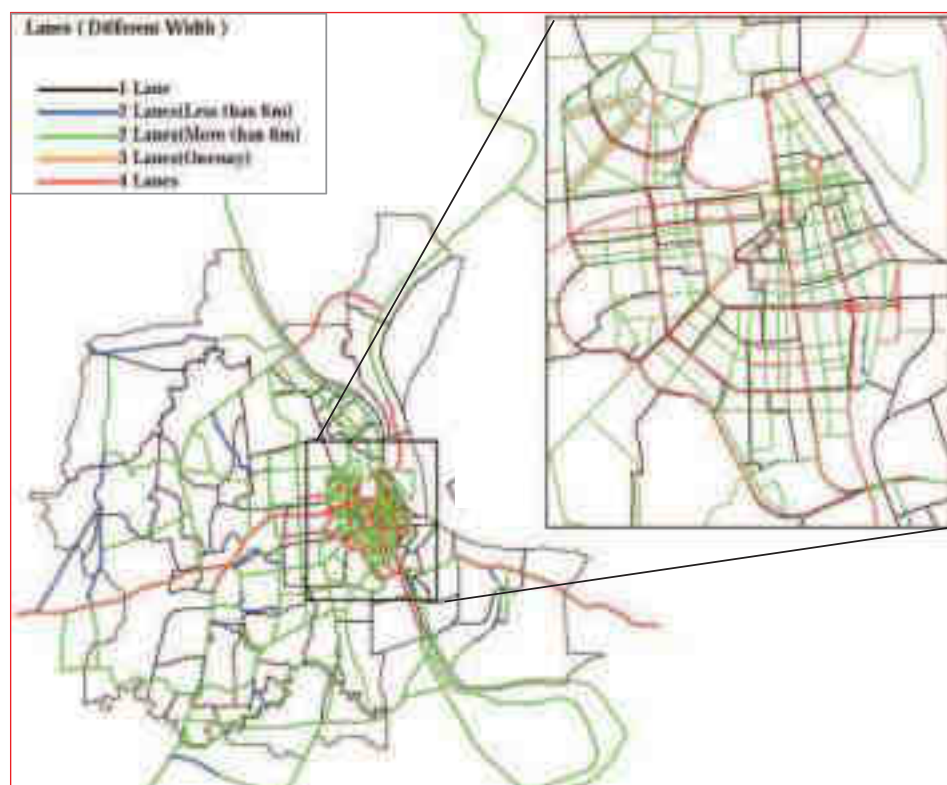


Figure 5.1. Road network of Phnom Penh (JICA-PUTMP, 2014)



Figure 5.2. (Left) the street networks in the inner Khans and (Right) the street networks in suburban Khans. Red dots represent the nodes and cul-de-sacs, and the light green represents the edges (Research Team, 2020)

The road network in Phnom Penh is composed of arterial, collector, and local roads, as illustrated in Figure 5.1. According to the Department of Public Works and Transport, the road network of Phnom Penh, as of June 2012, consisted of 1,379 km of total road length, equivalent to the area of 10,370 sq.km (JICA-PPUTMP, 2014). The arterial, collector and local roads accounted for 212 km (15%), 283 km (21%), and 884 km (64%), respectively. The arterial roads are typically 30m in width, i.e., 18m for the carriageway and 12m for the sidewalk. The typical width of the arterial roads in the urban area is 18m, usually dividing into 4 lanes for 4-wheeled vehicles and 2 lanes for motorcycles—which is important considering the facilitation of possible future re-assignments for softer modes or public transport (e.g. bike lanes, BRT lanes or light rail in median). However, the roadside is often used for parking vehicles or hawkers or commercial goods, assuming the actual use of road traffic for 4 lanes. In the suburban area, most arterial roads are 2-lane, except for the NR4 and NR1. Any arterial roads should be developed with 4-lane where possible, in general.

The road network patterns in the city demonstrate significantly different characteristics of street networks in the central and peripheral districts. Many primary

and secondary roads are disrupted due to topographical conditions such as rivers. The roads are not well connected due to the low density of streets, particularly in the suburban areas (Yen et al., 2019). Figure 5.2. illustrates the street density and connectivity between the inner Khans and outer Khans. The inner city districts have orthogonal street patterns, and the peripheral districts have dispersed patterns with a high density of cul-de-sacs. A common pattern that characterises street development in suburban areas is their lack of compliance with the Phnom Penh transport master plan, which turns them into “isolated” microgrid streets that have weak connection to the inner city. Those disconnected micro-grid streets between inner and suburban areas result from the influence from private developers and lead to those unplanned patterns that create connectivity inconsistencies. Because of these specific characteristics, the one way street measure may not efficiently apply to ease traffic mobility in those locations.

For specific sites such as the Southern zone or Sisowath, possible implications of a disconnection between transport and land use planning have been mentioned in previous work (City of Phnom Penh, 2019).

5.2. Ring Roads

Ring roads are built with the declared intention of connecting major mobility corridors (i.e., National Road 1, 2, 3, 4 and 5), helping ease traffic congestion in the city center and encouraging more development in the peripheral districts of the city. Also, their role in providing access from and to industrial and commercial sites near or within city boundaries for heavy goods vehicles is essential—while passenger transport is a core focus of studies and infrastructural investments, it should not be forgotten that freight haulage and cargo logistics share the same road space. Redirecting heavy vehicles to the outskirts of the city thus is a central function of ring roads.

The ring roads connect one corridor to another (e.g., between the National Roads 1 to 2).

Under the current planning, Cambodia needs approximately USD 9 billion to be invested into 850 km of roadways by late 2020, according to a study by Henan Provincial Communications Planning Survey and Design Institute that is behind Cambodia's expressway development master plan.

Figure 5.3 shows the development of ring roads for Phnom Penh (JICA-PPTUMP, 2014). The second ring road is now underway and runs 16.67 km across two lanes from Russian Federation Blvd to NR2 across the districts of Dangkor, Sen Sok and Meanchey heading south to Takmao town. It costs approximately KHR 72 million. The ground-breaking ceremony for the construction of the ring road No. 3 took place in 2019: with a total length of about 53 km, it connects Nrs. 1, 2, 3, 4 and heads to NR 5. The ring road No.3 stretches through Kandal Province for 38 km and Phnom Penh for 15 km

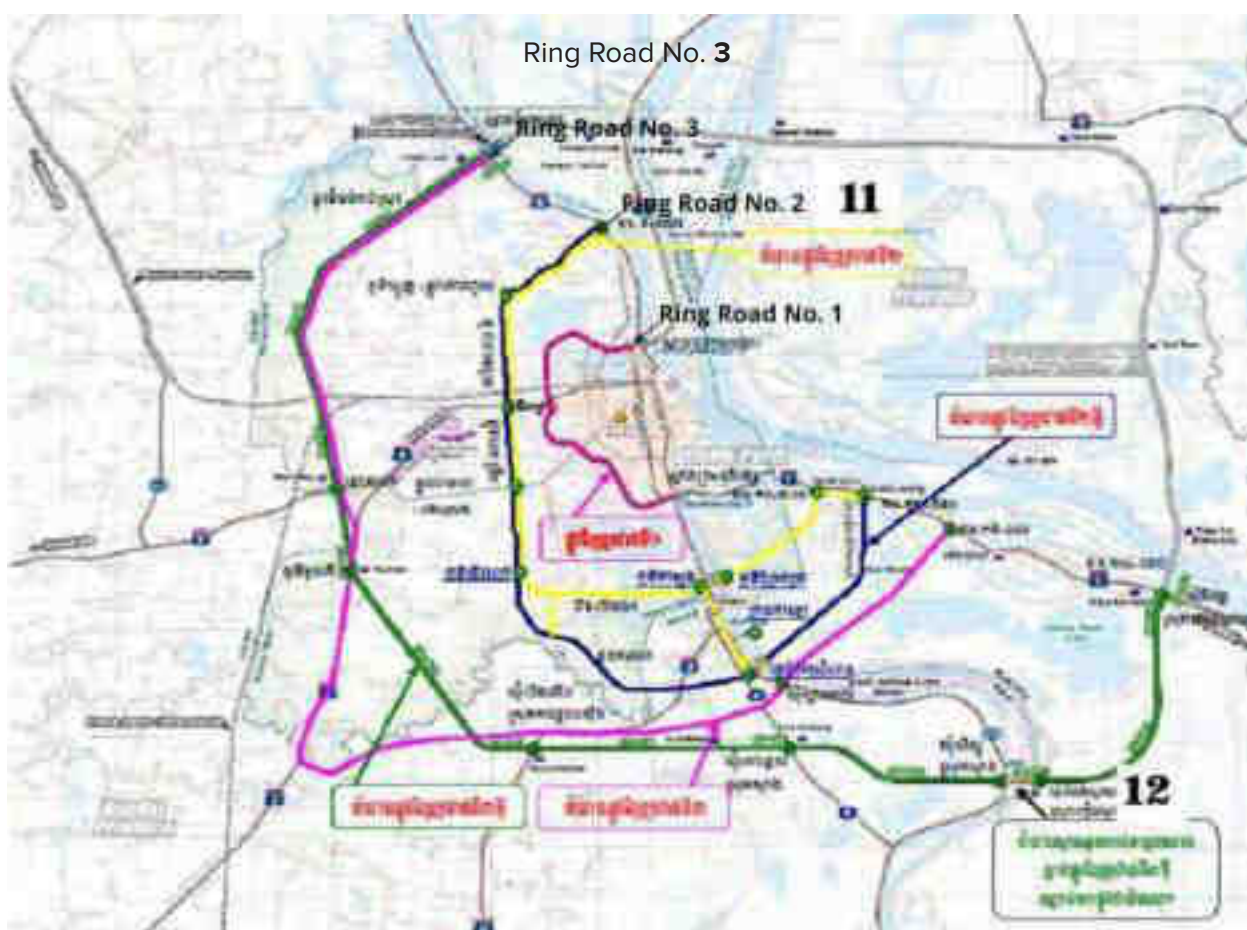


Figure 5.3. The development plan of ring roads for Phnom Penh (JICA-PPUTMP, 2014)



Figure 5.4. Airport Rail Link and Water Taxi Route in Phnom Penh, Aug 2019 (Research Team, 2020)

with the road width of 27 m in the urban area and 25 m in the suburban area. The road is being built using a USD 273 million loan from the Chinese government.

The remaining part, so as to ensure a 360 degree connection around the city center, consists of the link between the western and the eastern parts across the Mekong River, currently ensured by the ferry services.

5.3. Infrastructure for New Urban Public Transport Modes

Two new public transport modes, the Airport Train and Water Taxi Boats, have been made available from April 2018 on. Figure 5.4 shows their operating routes and stations. The public transport services of these modes were implemented by the Ministry of Public Works and Transport. They have been expected to serve as alternatives to help alleviate current and future road traffic congestion in Phnom Penh. The airport train provides a single point-

to-point link with only two stations, while the Water Taxi Boat serves one route with six stations.

While they need to be mentioned here for their role of replacing other types of infrastructure (missing commuter rail links or bridges), the details of these services will be explained in later chapters (6.1.2 and 6.1.3). Status Quo and Strategies regarding the different modes are discussed in more detail in chapter 7.

5.4. Bridges and Ferries

Another consideration of the current state of road transport infrastructure concerns Bridges and Ferries: Phnom Penh's urban center is linked by the Chroy Changvar bridge (Japan bridge) in the north and the Preah Monivong bridge in the southeast, while the suburban area is connected to Prek Pnov bridge in the north and Tonle Bassac Ta Khmao bridge in the southeast (Figure 5.5), alongside with smaller bridges that are essential in relieving the traffic flow along main bridges. Besides those

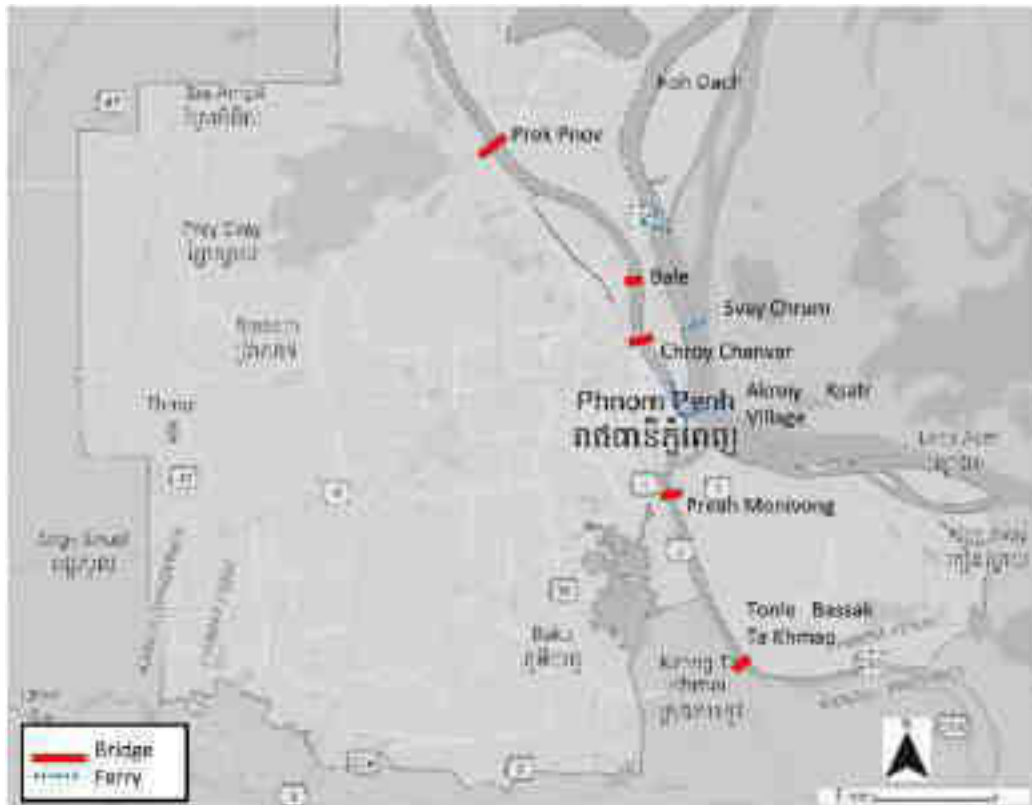


Figure 5.5. The connection between Phnom Penh and surrounding areas via bridges and ferries (Research Team, 2020)

bridges, there is no connection to the eastern side of Phnom Penh, although plans exist to build new ones.

Following a similar logic as explained earlier, ferries are operating on inner-city connections. Ferries serving in replacement of bridges are a source of considerable economic challenges resulting from slower, capacity-limited and more expensive transport connections. Examples are the connection between the city to the eastern side that are mostly provided by the ferries: These are indispensable to carry both passengers and cargo, for example from Phnom Penh to Arey Ksat (located about 2 km in the east of Phnom Penh), and vice versa. Figure 5.6 shows the passengers crossing the river to/from Phnom Penh via Ferries. The very basic layout of the landing sites illustrates in an exemplary manner that the existing bridges and ferries do no longer correspond to the rapid urban growth and expansion of Phnom Penh. As such further development of bridges

to connect the city to the eastern districts are important to improve the urban connectivity and reduce traffic congestion. Current traffic flows currently underserved by ferries represent the required volume calling for a bridge.

5.5. Sidewalks

Standard sidewalks have been designed and built for several major streets in Phnom Penh. However, these standard sidewalks are mostly non-continuous, and do not provide a network of sidewalks covering the entire urban area. Sidewalks are public land, but there is a lack of government enforcement to ensure the purposes of constructing and maintaining sidewalks. It also remains unclear which authority level should manage sidewalks and their relevant enforcement activities. As a result, currently most sidewalks in Phnom Penh are mainly being used for parking and business activities (Figure 5.7). These activities have obstructed pedestrians from using sidewalks,



Figure 5.6. Passengers boarding from/to Arey Ksat to Phnom Penh via ferries, Oct 2019 (Research Team, 2020)

forcing them to walk on traffic lanes instead, facing a high risk of collision with vehicles on outer lanes. Occupying sidewalks for parking and business activities further contribute to the deterioration of pavements and potholed surfaces, worsening the walking environment.

This unfit environment due to the current condition and use of sidewalks fundamentally affects citizens' perception of walking as a means of urban mobility; as a result, many rely on their private vehicles as preferred modes of travel, while walking is almost nonexistent in the modal share of urban trips (JICA-PPTMP, 2014). This profoundly affects not only different forms of walking as part of urban transport per se (origin-destination and recreational), but also the capacity of travellers to access the stops of the Phnom Penh city bus system, resulting in unattractive and thus less frequent public transportation. This makes the question of how to strategize and administer sidewalk

deployment and usability a core aspect of any consideration and planning for urban mobility in Phnom Penh, but also has significant repercussions on the cost of inner-city urban transport movements.

It was found that streets, sidewalks, and open public spaces within Phnom Penh cover only 16.4% of total space within the city. Streets and sidewalks cover 14.3%, which is quite low compared with Singapore (21.6%), but comparable to Bangkok (15.9%) and Manila (15.2%). The 2.1% of open public space in Phnom Penh (e.g., parks, places to exercise and for civic participation), is well below the international standard of 10.0% (figures: Sahmakum Teang Tnaut, 2018b). It was recommended (Sahmakum Teang Tnaut, 2018b) that more public space and walkability standards should be considered in urban planning in order to optimize economic development and social benefits.

Positive examples of sidewalks do exist, e.g. along the Preah Norodom Boulevard, where universal access for disabled persons was installed and where parking prevention on sidewalks is well-enforced. Similarly, sidewalks are being improved along Russian Federation Blvd, at different road segments, depending on available space (e.g. in front of Institute of Technology of Cambodia and Phnom Penh Airport). However, these sidewalks are not well connected to the adjacent streets, where sidewalks are again mainly used for parking or business activities.

5.6. Parking

The demand for parking space in the city by far exceeds the supply, resulting in parking-search traffic and other time delays. The availability, deployment, pricing and management of parking space play a key role in regulating the volume and fluxes of motorized individual traffic in and into a city: while an oversupply of cheap parking spaces would result in more car-based traffic, likewise insufficient parking space can drive up traffic volumes, resulting in increased traffic congestion, accidents and air-polluting emissions as vehicles continue to either directly access or cruise for available parking spots.

As Shoup (2005) explained in his groundbreaking work, it is especially free or low-cost, inadequately priced parking, as is available in most sites in Phnom Penh, that comes with a high amount of externalized costs, mostly resulting from the occupation of otherwise highly valuable, premium urban space and the induced car dependency. The latter also implies severe negative effects on the structure of urban form, international experiences from all contexts showing that the unavoidable emergence of a car-centered urban resulting from a perceived availability of free parking creates wrong incentives on car usage ultimately resulting in external costs that ultimately have to be borne by society.

Shoup's analysis is transferable to the Phnom Penh context: Without strategies for the (non-) implementation of and strict enforcement of parking rules as well as an adequate supply of parking space, vehicles will continue to be seen parking on sidewalks or in traffic lanes, hindering pedestrians and city buses. Both an oversupply and an undersupply trigger undesirable external costs; Shoup emphasizes that the planning, regulation and pricing of parking need to be strictly aligned with urban planning measures.

According to JICA-PPTMP (2014), there is a shortage of parking spaces for motorcycles and cars in Phnom Penh. Even though streets are being occupied by street vendors, other street sides (known as “shoulders”) and pedestrians' sidewalks have become parking spaces, which result in traffic flow disruption and safety concerns. It was indicated that the central districts need 12,000 spaces for motorcycles and 6,000 spaces for cars. There is no accurate data regarding numbers and spaces available for vehicle parking in the city. Phnom Penh Municipality emphasized that there are 12 parking lots in the city with a total area of 937,328 m². Also, newly developed underground parking lots comprise 41,670 m² of parking space (The Phnom Penh Post, 2019). However, these spaces do not correspond to the current numbers of motorized vehicles estimated to be more than 2 million (source: Ministry of Public Works and Transport).

In the commercial and business center, the average parking fee is about KHR 500 per hour for Motorcycles and KHR 2,000 per hour for cars. These fees are collected by privately hired guards for the use of private or “privatized” land—the latter often being publicly owned sidewalks in front of privately held real estate (both commercial or residential). This practice presents main aspects typical of informal businesses (ILO International Labour Organization, 2013). These parking schemes, though mostly similar by structure



Figure 5.7. Sidewalks are occupied for parking (left) and privately managed for parking (right), Aug 2019 (Research Team, 2020)

and function, are locally organized and neither licensed, nor coordinated or administered by the Municipality of Phnom Penh. Adding to the missing oversight, this results in a lack of municipal revenue from paid parking. One prominent trial with a licensed paid parking system on public ground failed (see appendix 15.1). Several attempts a few years ago to use public agents in order to regulate and reclaim public parking spaces by collecting parking fees with regulated tariffs (such as on several parts of Monivong Boulevard) were also discontinued.

As the number of motorized vehicles in the city continues to grow, more parking spaces are needed, further worsening the misalignment of supply and demand. Following the city's expansion, several new infrastructure projects integrated proper parking lots but most of them are large scale development projects. . Figure 5.8 shows examples of new residential buildings and shopping malls with raised parking lots. In addition, two large public underground parking lots of projects are under construction in or near the city center (The Phnom Penh Post, 2017)—one in proximity of the US embassy and the other in front of the

central railway station / Vattanac Capital Tower (Figure 5.9).

More city-run or licensed Park-and-Pay systems for on-street parking are being considered in Phnom Penh to help liberate the sidewalks and provide a base for enforcing proper parking behavior. The fee collected from parking would be used for pedestrian and parking infrastructure development.

Although more official parking spaces may lead to fewer vehicles parked on sidewalks, and thus a better walking environment for pedestrians and better traffic in the city, the evolution of vehicle registration numbers outnumbers the increase in official parking by many orders of magnitude: It is estimated that between 2014 and 2020, the number of registered cars increased by approximately 24,000 (car registrations: 84,426, increase in official parking spots: 8,400). Thus, it becomes obvious that increasing the supply in parking spaces cannot be part of a sustainable strategy of improving urban mobility in Phnom Penh: Figure 5.10 clearly shows that the total increase in car parking spaces in Phnom Penh is outnumbered by the increase in the car



Figure 5.8. New residential building (left) and a mall (right) with parking lots, Oct 2019 (Research Team, 2020)



Figure 5.9. Construction of underground parking lots in front of the US Embassy (left) and Central Railway Station, Aug 2019 (Research Team, 2020)

population. As further discussed in chapter 13, the only long-term solution aligning social, economic and ecologic interests can be an institutionalized shift away from car-based urban transport.

Figure 5.10. The increase in the number of registered cars and additional parking space required in Phnom Penh 2014-2020 (Source: Calculations by Research Study Team, using data sources from JICA and CSES)

5.7. Infrastructure Performance

The role of punctual and micro disruptions in a wider transportation system, such as road accidents, floodings, construction work or short-term street closures due to diplomatic visits, are easily underestimated, but in a system-wide consideration can significantly affect the performance of infrastructure. For transit networks entirely relying on their own right-of-way, specific disruption protocols are

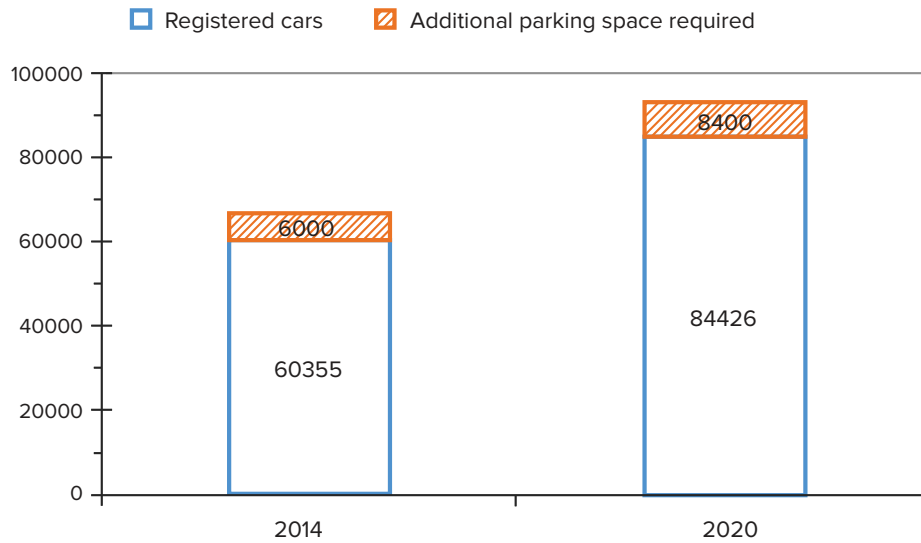


Figure 5.10. The increase in the number of registered cars and additional parking space required in Phnom Penh 2014-2020 (Source: Calculations by Research Study Team, using data sources from JICA and CSES)

generally in place including fallback procedures such as bus bridging between stations at the extremities of a temporary disruption zone. The following section shall be a short reminder to not forget similar considerations when designing or altering roadway networks.

5.7.1. System Stability and Disruptions

Normally, links e.g. between major arteries in an urban road network are assessed according to their role in supporting the efficiency of the overall network under normal operating conditions. However, small accidents or other disruptions originating from transportation-related or external conditions can expose the vulnerability of roadway networks depending on the site, time and gravity of their occurrence. This highlights the importance of redundancy in all planning for new construction, amendments or upgrades of road networks. With this in mind, Jenelius (2010) has analyzed the role of links with regard to robustness of transportation on a road network. This includes choosing an impact-based measure, in contrast to a flow-based measure traditionally used in assessing networks. Jenelius considers how much a link

contributes by comparing it to the case where it wouldn't be available, thus being able to assess its contribution in terms of avoided impacts. Key findings include that while specific links may not have much importance for network operations under normal conditions, they can save significant negative impacts in a case of disruption, thus justifying the investment in their construction and upkeep.

As a recent example, small temporary roadblocks at the level of Wat Phnom or Russian Boulevard at early morning peak hours to allow passage for official delegations can significantly impact the whole traffic system, and many thousands of road users, up to RN1 Boeung Snoul, as all main boulevards (Monivong, Norodom, Mao Tse Tong) as well as secondary roads get saturated. The distance/time ratio increases from 5 up to 10 times, even leading to almost full system inertia if the micro disruption occurs during exceptional peak time, as the road system meets its maximum carrying capacity in a very short time, such as during the week that precedes Chinese New Year. This traffic saturation occurs despite efficient regulations of traffic ensured by police forces at all critical junctions.

5.7.2. Options for Improvement Measures

In the above given example, avoiding information asymmetries can help relieve traffic saturations at no major cost. Clear communication on expected disruptions, announced whenever possible via popular channels and digital media a few days in advance, would allow road users to be informed and adapt their plans accordingly. This first, simple measure could have an efficient mitigation effect as it may lead to better distribution of traffic flows during a specific time period.

The role of links in disruption situations is to be critically reviewed as part of all decision-making affecting the redesign of Phnom Penh's road network, especially with regard to decisions on entirely, partly or conditionally blocking smaller streets for cars or turning them into one-way streets. This should include specific considerations such as the importance of redundancy, rerouting or backup options or access by emergency vehicles.

Likewise, the planning of future on-street parking, cycling routes, transit corridors and priorities, and inter-modal options for routing choices must be part of such considerations. Options include linkways such as sections of road that in normal operations would only be used by transit vehicles, but in the event of a disruption become temporarily available to other vehicles, which is compatible with the underlying recommendation to gradually work towards a transit-based urban mobility in Phnom Penh: Privileging bus transit by accelerating it and stabilizing its operation through access to dedicated sections of road that can serve as emergency backup thus is a key element in a low-cost approach to making road transport in Phnom Penh more efficient as a whole.

Decision-making on such temporary re-routing needs to be part of a centralized traffic management. The identification and assessment of the criticality of specific links can be undertaken in an agent-based simulation

Key Takeaways:

- The road networks in Phnom Penh are not well connected due to the low density of streets and intersections, particularly in the suburban areas.
- Improvement of the connectivity of the road infrastructure, including ring roads and bridges crossing rivers.
- Existing spaces of sidewalks are occupied by vendors and illegal parking activities. Proper sidewalks encourage pedestrian movement and accommodate the demand for non-motorized transport—thus promoting social interaction and public health.
- More parking spaces are required to accommodate the increasing number of registered vehicles in the city.

6. PUBLIC TRANSPORTATION

Summary:

This chapter discusses public transportation in Phnom Penh. The current array of publicly accessible transport modes in the city include both fixed-route systems running large vehicles as well as on-demand systems operating smaller vehicles that can be flexibly dispatched. A brief presentation of the main modes is given in the following sub-chapters together with some compact, critical remarks on their present role within the urban mobility ecosystem.

Public transportation modes include Motodop, auto-rickshaw, Long-tailed Remork, Cyclo, Taxi, and a Public Bus Service. A brief presentation of the modes is provided in the following sub-chapters. It is crucial to note that currently the largest passenger volume is handled by the total of various on-demand modes.

6.1. Fixed-Route Transportation

Like other Asian developing cities, Phnom Penh faces serious traffic related issues such as traffic congestion, traffic accidents, and air pollution.

These issues have increased travel time and cost and slowed down economic activities. To remedy the problem, the government has considered several alternative modes of mass transit systems (e.g., AGT, BRT, Tramway, Public bus), but only a public bus service has been introduced in the city. It is supplemented by,



Figure 6.1. The brochure of bus route map in Phnom Penh, Aug 2019 (Source: City Bus Authority)



Figure 6.2. Onboard Fare Collecting System (left), StopsNearMe app (middle) and City Bus app (right), Nov 2019 (Research Team, 2020)

but currently not integrated with, a scheduled boat service and a rail link between city and airport.

6.1.1. Public Bus

For the history of the public bus service in Phnom Penh, see Appendix 15.2.

Current state

As of 2019, the public buses are operated on 13 routes in the city (Figure 6.1), using a fleet of around 200 buses. The bus services are available from 5:30 to 20:30 daily. The bus headway ranges from 5 min to 20 min depending on bus operating routes. On average, approximately 25,000 passengers are using public buses daily—among which up to 60% were identified as free riders.

The fare for boarding a public bus remains KHR 1,500 (USD 0.37) per trip. This fare is flat (not a distance-based fare), and passengers are required to buy a new ticket when transferring from one bus to the other. Passengers can pay by scanning QR code, scanning IC, or putting fare into fare collecting box, available onboard.

During the early stage of the bus services, there were two persons on the bus—the driver and the ticket conductor who sold and validated the ticket and fare. Now, paying for the bus fare is automated via smartphone or IC, and only the driver onboard validates the fare/ticket. Figure 6.2 shows the fare collecting system and mobile apps for public bus services in Phnom Penh. A free fare policy applies to specific groups of passengers. As of 2018, senior citizens (over 70 years old), children (under 1 meter), disabled persons, monks, teachers, students, and factory workers (until September 2019) could travel free, upon confirmation of their identity with student cards, teacher cards or working cards etc..

The public bus services have also been upgraded with mobile applications such as “StopsNearMe – Phnom Penh Bus” and “City Bus Official” apps. The apps provide limited information about the bus stops, available routes, and the real-time locations of buses running in the Phnom Penh. With one’s current location on a smartphone, he/she can easily decide which bus stop is the nearest and which bus lines to transfer to in order to arrive at a specific destination.

Issues

The public bus was introduced with optimism, but lacks sufficient infrastructure to support its smooth operation. For instance, most of the bus stops are on roadsides that have been labeled as “Bus Stop” with lane markings and a station pole, which while being a starting point, falls behind global standards. Even later, more bus stops have been improved, providing them with shelters and seats, but are still inadequate with regard to convincing citizens of a wide-spread use and true alternative especially for paying customers. There are no specific (paratransit) stations for intermodal passengers.

Sum et al. (2019) evaluated the public bus service quality from users’ perspectives and found various issues including the lack of public bus services to cover both urban and suburban areas, poor conditions of road infrastructures (e.g., small, unpaved), and bus stop facilities (e.g., shelters and roof). The authors argued that it would require more than 200 buses with the headway of every 15 minutes to fulfill the demand for public bus services in the suburban areas. However, there is less population density in the suburban areas, so the bus service, in providing longer rides into less lucrative areas, would operate at an even higher deficit.

Further, the buses are operated at a slow speed in the mixed traffic. The general traffic volume along Monivong Boulevard has increased by more than 34.0% since 2000, and the average operating speed of the bus was also observed to decrease from 13.9 kph in 2001 to 9.9 km/h in 2014. Overall Improvement of bus operations, especially average travel speeds, frequencies and service reliability, is important to attract more passengers during peak hours. The walking environment as a means to access bus stops remains poor. Many sidewalks are occupied by parking cars and business activities along the streets.

Improvement of Bus Corridor

There has been a discussion by the JICA study team about how to improve bus services (e.g., speed). One of the strategies proposes the use of bus priority lanes. JICA is studying the possibility of converting a segment of bus route #4, between Central Market and Steung Meanchey Intersection (i.e., about 5 km). Among all operating bus routes, bus route #4 (i.e., 4A, 4B, and 4C) has the highest number of passengers, more than 7,000 passengers per day.

While this can be an important starting point to make the bus corridor #4 both economically more efficient (fewer vehicles needed for the same number of passengers transported due to higher speed), a single bus corridor will stay behind its potential if not part of a network. The commercial speed distribution on Jakarta’s BRT system (Transjakarta) shows that beyond corridors, the management of the intersections is also crucial (bus detection and prioritization, physical clearing of intersection).

Location of Intercity Bus Terminals

An important element to reconsider when fluidifying travel chains and providing a true alternative to the use of privately held cars for medium- and long-distance travel is understanding the way that intercity buses and shared minibus taxis used for long-distance travel connect to Phnom Penh’s urban transportation system.

The current plan is to relocate the intercity bus terminal to a peripheral location. While this allows for intercity buses and minibusses to avoid urban traffic congestion, an efficient way for passengers to get to and from the long-distance coaches needs to be provided. Thus, the intercity bus terminal’s new location needs to have high-quality and -frequent connections to Phnom Penh’s core and outskirts, ideally by having good access to core Phnom Penh City bus routes, and later to the form of mass transit

that is chosen. Any type of disconnected, standalone solution would mean a loss of attractiveness and efficiency.

6.1.2. Airport Train

Current Service

The airport train shuttle service has been running in Phnom Penh since April 2018. The train service is available between Phnom Penh Station (or Central station) and Airport Station, from 6:00 to 20:00, around once every 30 minutes, and with a fare of USD 2.50. Currently, it is observed that one train is in operation, with one conductor and one assistant. Its speed is a slow 20 kph, measured by the authors to sometimes further slowing down to 12 kph for safety reasons (i.e., to avoid accidents with road surface traffic). One problem is service frequencies affected by resulting delays, given that normal operation of the airport service is with one single diesel-powered railcar (DMU) only. Since the train passes through general road traffic, the conductor would slow down

the train when facing traffic risks of interference with general vehicular traffic along the track. In addition, there are no stations between the start and end stations, reducing the attractiveness of the airport train service to local citizens.

The research team found that the number of passengers using the airport train service was very low, with many trains running entirely empty, and that the non-adherence to the timetable was perceived as a major inconvenience by the potential travelling public.

However, an aspect highlighted by the CEO of the Royal Railway Group currently operating both freight and passenger rail services in Cambodia needs to be taken into account: The deterioration of rail infrastructure after the civil war ultimately had led to the total abandonment of rail services, and the platforms had been adopted by citizens for storage, household use and local foot travel. After the reintroduction of limited rail services following the refurbishment of the main rail corridors funded by Australian development aid funds, a great number of



Figure 6.3. The Airport train crossing the main road in front of the Airport (Research Team, 2019)

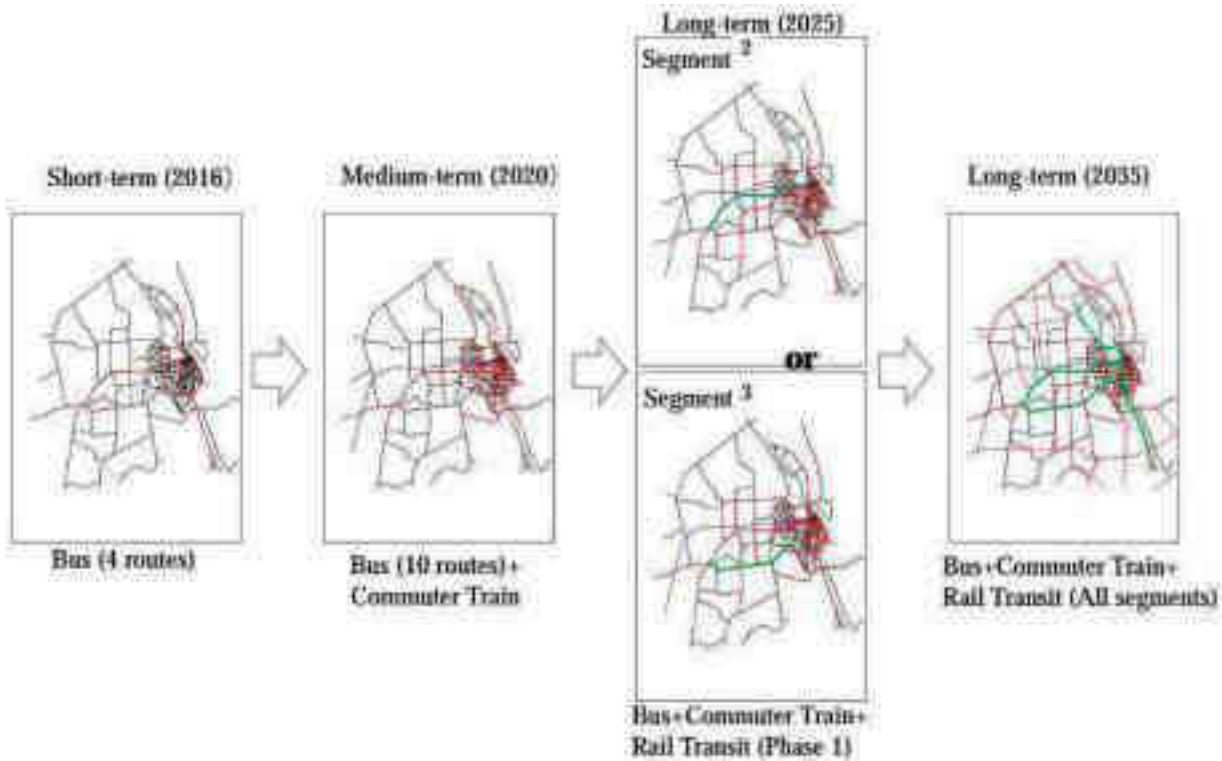


Figure 6.4. The development plan for the urban public transport network (JICA-PPTUMP, 2014)

service disruptions in the Phnom Penh urban area—especially of the profitable freight services that also greatly reduce long-distance road freight where they operate—were due to citizens having lost the habit of train services running, often ignoring the most basic safety measures. Thus, the airport train also fulfils the function of “track clearing” with its regular runs—a classic technique in rail operations familiar in comparable ways also in Europe and North America. Figure 6.3 shows the appearance of the rolling stock, imported from Mexico. These made-to-measure DMUs (self-powered diesel motor units) have been built to be of heavy enough construction to safely withstand possible collisions with road vehicles without easily derailing, while being economical on fuel consumption, and to be of flexible use also for long-distance services to Sihanoukville.

These insights won from the reintroduction of passenger rail services will be highly valuable with regard to the step-by-step implementation of urban rail services in Phnom Penh.

Planning for Inner-City Local Transport Commuter Service

JICA-PPUTMP (2014) has proposed the public transport network development for Phnom Penh as shown in Figure 6.4. In the early stages, there would be four bus routes in 2016 (short-term plan). By 2020 (medium-term plan), the bus routes should be expanded to ten bus routes, and a commuter train would also be considered. By 2025 (long-term plan), one route of mass transit service should be implemented, while the bus route network should be restructured to complement the feeder services of the mass transit stations. The mass transit systems under consideration could be Automated Guided Trains (AGT) and/or Tramways. From 2025-2035, more mass transit routes should be expanded. Currently, there are 13 bus routes, one railway route of airport train, and one route of Water Taxi boat serving as public transport services in Phnom Penh. However, these services fail to address the needs of the wide majority of the city’s commuters, who must still depend on their

private vehicles such as motorcycles and cars. More investment in public transport systems, especially in dedicated infrastructure, is needed to improve the overall quality of public transport services, which in turn encourages citizens to shift from private vehicles to using public transport systems. At this point, reliability, including on-time performance, are major issues.

6.1.3. Water Taxi

Following the Airport Train service, Water Taxi services, connecting the north side with the south side of Phnom Penh via waterway, were also launched in April 2018. At first, it was planned to have six boat stations (except Prek Phnov Port), with a total operating length of about 19 km, along the Tonle Sap and Tonle Bassac rivers. Figure 6.5 shows the facilities of the Water Taxi system.

Table 6.1 shows the current schedule for Water Taxi services. According to the Ministry of Public Works and Transport, there are four Water Taxi boats, but only three of them are in use (Boat No. 3 is unavailable), providing water taxi services between five stations (Prek Pnov station is unavailable) from 7:00 to 17:00. Boat

No. 3 was in maintenance. In addition, Prek Pnov station was not in use, which the authors relate to low passenger demand—Sangkat Prek Pnov is a suburban area with relatively low residential density.

The Water Taxi boat takes approximately one hour from one end to the other, including in-vehicle and boarding time. Approximately a hundred passengers use the Water Taxi service each day, and they pay a fixed fare of KHR 2,000 (USD 0.5).

However, determinants of taxi boat mode choices made by citizens have never been investigated. Understanding the determinants of travel mode choice is the prerequisite to designing proactive, consistent policy to promote taxi boat usage. Additionally, the time table is not organized using any scientific approaches, and this degrades the efficiency of passenger transportation. Beyond that, data on passenger capacity of embarking and disembarking at each station is not uploaded online for public usage, which restricts participation from scholars and researchers intending to study potential improvements to taxi boat usage and an appropriate optimization of the taxi boat timetable.



Figure 6.5. Passengers boarding Water Taxi Boat (left) at Russey Keo Station (right), Oct 2019 (Research Team, 2020)

Table 6.1. Schedule of Water Taxi Boats in Phnom Penh, as of Nov 2019 (Source: City Bus Authority)

Time	Morning					Afternoon			
Direction	From Russey Keo Station to Ta Khmau Station								
Boat No.	1	2	3	4		1	2	3	4
Russey Keo Station	7:00	7:30	9:30	10:00	Time break	13:00	13:30	15:30	16:00
Old Market Station	7:20	7:50	9:50	10:20		13:20	13:50	15:50	16:20
Chaktomuk Station	7:30	8:00	10:00	10:30		13:30	14:00	16:00	16:30
Chbar Ampov Station	7:40	8:10	10:10	10:40		13:40	14:10	16:10	16:40
Ta Khmao Station	8:00	8:30	10:30	11:00		14:00	14:30	16:30	17:00
Direction	From Ta Khmau Station to Russey Keo Station								
Boat No.	3	4	1	2		3	4	1	2
Ta Khmau Station	7:00	7:30	9:30	10:00	Time break	13:00	13:30	15:30	16:00
Chbar Ampov Station	7:20	7:50	9:50	10:20		13:20	13:50	15:50	16:20
Chaktomuk Station	7:30	8:00	10:00	10:30		13:30	14:00	16:00	16:30
Old Market Station	7:40	8:10	10:10	10:40		13:40	14:10	16:10	16:40
Russey Keo Station	8:00	8:30	10:30	11:00		14:00	14:30	16:30	17:00

Water Taxi services should thus be further improved on the basis of scientific studies such as the ways to optimize the Water Taxi stations and timetable, and better connect them to other modes. This optimization would inform operators/users of the most reliable travel time.

6.2. PARATRANSIT: ON-DEMAND SERVICES

Even after the introduction of the public bus, Airport train, and Water Taxi services, citizens largely depend on paratransit modes to travel around the city. The common urban paratransit modes include Motodop, Auto-Rickshaws, Long-tailed Remorks, Taxis, and Cyclos.

6.2.1. Motodop

Motodop, generally known as motorcycle taxi, typically carries two adults with one child at most. Motodop service is very popular due

to its ubiquitous availability in the city, the ability to penetrate through narrow spaces and congested traffic, its flexibility, and its relatively cheap fare. On average, Motodop drivers operate 11.5 hours, make 7.9 trips and transport 11.4 passengers per day (Phun et al., 2015b). They could earn about USD 180 per month. About 70% of the Motodop drivers are not citizens of Phnom Penh. Many drivers (up to about 77%) operate without a driving license, suggesting their limited knowledge of general traffic laws. As a result, they have been criticized for poor driving behavior, leading to safety issues. Phun et al. (2018) identified that approximately 40% of the Bajaj drivers with ride-hailing apps were former paratransit drivers, among which about 10% has upgraded their paratransit services from Motodop to Bajaj with ride-hailing apps. The number of Motodops has declined in recent years, and will probably continue to decrease, following the expansion of ride-hailing services (e.g., Grab, PassApp).



Figure 6.6. Remork (left) and Bajaj transporting passengers in Phnom Penh, Aug 2019 (Research Team, 2020)

6.2.2. Auto Rickshaws

Auto-rickshaws include Remork, Long-tailed Remork, and other motorized three-wheelers. Auto-rickshaws are more attractive than Motodop in terms of safety, comfort, and transport capacity (up to six passengers). Remork is a two-wheeled carriage pulled by a motorcycle.

Remork is also locally known as TukTuk or three-wheeler, despite being a four-wheeled vehicle. On average, Remork drivers operate 12.3 hours, make 4.1 trips and transport 10.5 passengers daily. They could earn about USD 250 per month. Recently, the number of other motorized three-wheelers have increased on the city streets. Private companies imported these three-wheelers from countries such as China and India. As an example, “Bajaj” refers to those motorized three-wheelers imported from India (e.g., Bajaj, TVS, Piaggio), while “Chinese auto-rickshaws” refer to those motorized three-wheelers imported from China. Figure 6.6 shows the appearance of Cambodian Remork and Indian Bajaj. Compared to other types of auto-rickshaws, Bajajs are more compact and standardized vehicles with a maximum speed of 60-80 km/h. While Remorks and Chinese auto-

rickshaws consume gasoline, Bajajs consume either gasoline or Liquefied Petroleum Gas (LPG). LPG is considered to be a much less polluting energy source, therefore less harmful to the city’s environment. In average, Bajaj drivers work 10.3 hours, make 14.5 trips, and transport 20.8 passengers per day (Phun et al., 2018). Bajaj drivers can earn about USD 430 per month.

On the other hand, Cambodia, compared to other countries in the world, has one of the highest rates of citizens living with physical disabilities. Yet, only very limited paratransit options were made accessible to them. In 2018, a Phnom Penh based and crowdfunded initiative called “Mobilituk” started fundraising and building two accessible Remork prototypes that are currently undergoing testing for technical and commercial feasibility.

Long-tailed Remork has a longer carriage than normal Remork, some with roof and some without roof, carrying up to 20 passengers. Long-tailed Remork has been banned in downtown areas due to safety concerns. It is now only allowed to operate in the suburban area on fixed routes and non-fixed timetables. The majority of Long-tailed Remork passengers are likely to be low-income individuals and students.



Figure 6.7. Accessible Mობilituk (Remork) with wheelchair ramp deployed (Research Team, 2020)



Figure 6.8. Accessible Mობilituk (Remork) in non-wheelchair mode. Note the sleek stainless steel construction complemented by traditional décor elements (Research Team, 2020)

6.2.3. Metered/Ride-Hailing Taxis

When they were introduced to Cambodia in 2008, metered taxis backed-up by dispatching call centers have become popular, being safer and more comfortable compared to other paratransit services available. Taxi services can

be booked in advance via a telephone call or a ride-hailing app, or can be directly hailed in the street. Available ride-hailing apps for Metered Taxis include PassApp, Grab, iTsumo, and WeGo. Normally, the Taxi fare is charged based on distance travelled or a metered-taxi system, ranging from KHR 2,000 (USD 0.5) to KHR

4,500 (USD 1.1), with KHR 2,000 per additional kilometer. The government can regulate Metered Taxi services, but not other paratransit services provided by many individuals and informal actors. The municipality of Phnom Penh plans the introduction of a citywide Taxi service, but only a few metered-Taxi companies are at this time operating in the city.

6.2.4. Cyclo

Cyclo refers to a rickshaw with three-wheels powered by a human. Cyclos were first introduced in Cambodia in early 1960s by the French. The Cyclo Conservation and Careers Association (CCCA) reports that of about 1,000 cyclo drivers in Phnom Penh, 476 are members of CCCA. The Cyclo drivers earn approximately USD 85 a month on average, at a rate of 25,000 to 30,000 riel per day of work. The popularity of cyclos has declined due to increasing availability and price accessibility of motorized vehicles. Currently, Cyclos are mainly used by tourists, for short-distance trips, and mostly found around local markets. Today, there are only a couple of hundred left.

6.2.5. Regulatory Issues

Currently, there is no specific regulation to control and manage paratransit services in Phnom Penh—there is only registration for paratransit vehicles, but not for the drivers. The government has registered auto-rickshaws since 2009. According to the Department of Public Works and Transport (DPWT), the number of registered auto-rickshaws increased from 18,030 in February 2018 to 29,288 in November 2018—among which, the number of Bajajs quickly increased from 3,232 to 14,338, while the number of Remorks remained unchanged at 10,091 (Phun et al., 2019). The rise of the Bajaj is due to the gaining popularity of ride-hailing services. The Bajajs' fare is also substantially lower than the existing Remorks with or without ride-hailing apps.

Further, as there is no official control over Motodop operations (e.g., license, registration), anyone who owns a motorcycle could become a Motodop driver. As a result, the number of Motodops in Phnom Penh remains unknown. This unknown and unpredictable element in the paratransit mix also negatively affects safety issues and results in an oversupply of paratransit services.

6.2.6. Significance

The appearance and steep rise in the number of Bajajs has resulted in dramatically altering the urban traffic situation in Phnom Penh since the establishment of the JICA reports in 2014, and is considered to be one of the most important by the authors of this report. Re-counts on traffic in November 2019 in road cross sections comparable, but not identical to those chosen by JICA, show notable differences in growth that, through the methodology of road space occupation as laid out in chapter 10.2., leads to notable rises in congestion and related costs:

Figures 6.9 and 6.10 show the comparison results of modal share, between 2012 & 2019, along Russian Blvd and along National Road 6, respectively. The locations of the traffic count survey are shown in appendix 15.3. The proportion of motorcycles at both locations has increased over the last decade by approximately 10-14% extra. The proportion of passenger cars has decreased by approximately 9-13%. However, the new share of Bajajs came up in the meantime, now making up approximately 8-11%. The proportion of Bajajs in Phnom Penh was also verified with traffic data at the end of 2019 from other survey locations. Overall, the proportion of Bajajs on Phnom Penh streets, observed at four different major streets, has significantly increased from 0% in 2012 to between 8.2% to 11% (with the average of 9.4%). It should be noted that Bajajs arrived in Phnom Penh together with online ride-hailing services, thus gaining popularity when compared with traditional taxi/paratransit services.

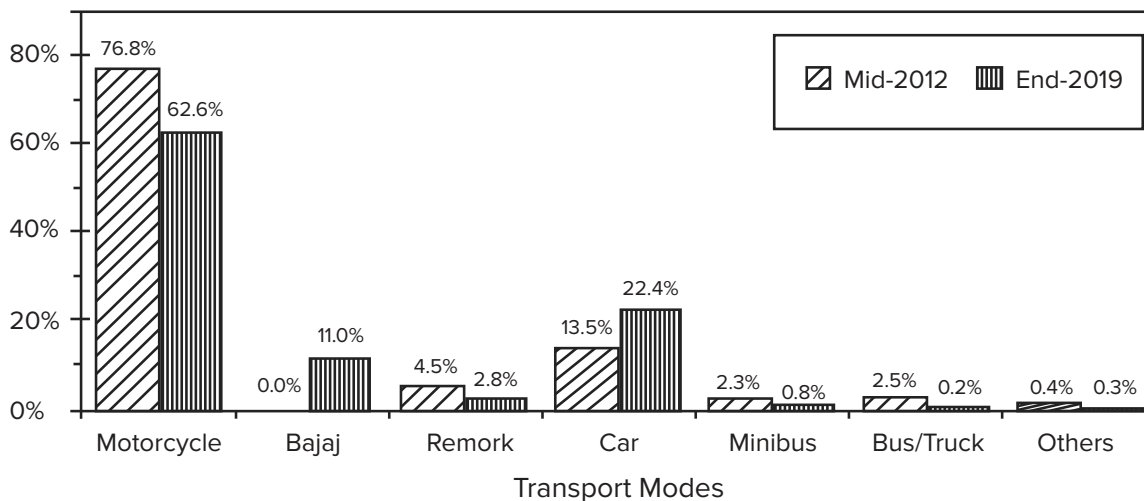


Figure 6.9. Comparison of modal share along Russian Blvd between the traffic count surveys in mid-2012 (24-hour traffic count, with total traffic volume of 168,552 vehicles) and in end-2019 (13-hour traffic count, with total traffic volume of 135,400 vehicles) (Research Team, 2020)

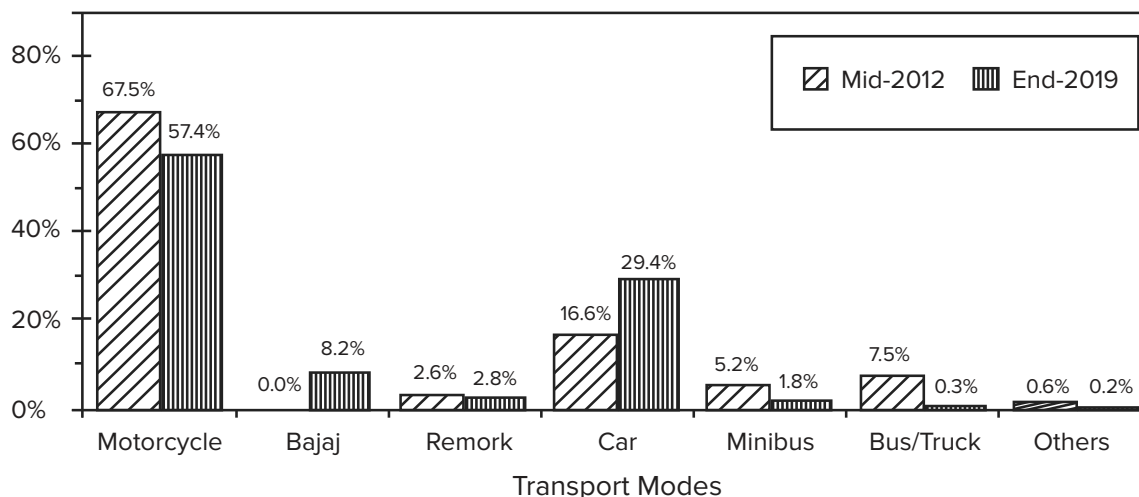


Figure 6.10. Comparison of modal share along National Road 6 between the traffic count surveys in mid-2012 (24-hour traffic count, with total traffic volume of 60,618 vehicles) and in end-2019 (13-hour traffic count, with total traffic volume of 54,838 vehicles) (Research Team, 2020)

Key Takeaways:

- The rapid increase in privately owned vehicles, along with insufficiency of traffic facilities and road carrying capacity leads to serious traffic congestion and accidents.
- More public transport modes have been introduced and expanded: Public bus services from 2014, ride-hailing services since 2016, airport rail link and water taxi services since 2018.
- Re-counts on traffic at 5 different major streets in Phnom Penh showed a significant increase in proportion of Bajajs from 0% in 2012 up to 11% in 2019.
- As a consequence, the current situation in public transportation is a source of serious challenges related to the efficiency of the use of public road space, of the widespread availability of low-cost public transport services, and ultimately of social equity.

7. LOGISTICS AND COMMERCIAL CARGO TRANSPORT

Summary:

This chapter provides an overall view of urban cargoes, street vendors, waste management, and heavy freight haulage. Special attention is paid to the current public streets, which have been occupied by a chaotic mixture of freight-carrying and general vehicles.

Many studies on urban mobility focus on the passenger transportation side only, omitting the fact that passenger and cargo logistics have to share the same restricted space, especially in dense urban areas. The broad approach that this report adopts does not allow for an estimation of direct and indirect costs of the current situation without taking relevant forms of urban freight into account.

7.1. Urban Cargo Vehicles

The volume increase in cargo logistics has posed considerable challenges for urban mobility in Phnom Penh.

Cargo is picked up or delivered by a bewildering and highly creative mix of vehicles, ranging from non-motorized two-wheelers up to motorized four-wheelers, at shops/offices/residences

along urban streets. Figures 7.1-7.4 show various representative forms of cargo logistics in Phnom Penh. Usually, the delivery industries use more standardized vehicles, that are in the form of four-wheeled vehicles, including Pick-up trucks, mini trucks, and cargo trucks. Some food delivery companies that handle orders via mobile phone or apps, use motorcycles as the fastest mode.. Motorcycles are also used for other goods delivery services (Figure 7.4). Several vehicles are locally made, and well below standards for vehicles transporting goods. The ways these vehicles transport cargo are often seen as a disturbance to the overall traffic flow—sometimes leading to traffic accidents due to the way that cargo is organized on the vehicles and the vehicles types themselves. On-street or off-street parking for loading/unloading cargo at a point close to the final destination, may often be a cause for traffic congestion.



Figure 7.1. Typical cargo cart (left) and motorcycle transporting goods, Aug 2019 (Research Team, 2020)



Figure 7.2. Passenger Remork (left) and Cargo Remork (right) in Phnom Penh, Aug 2019 (Research Team, 2020)



Figure 7.3. Mini-truck transporting construction equipment in front of Airport, Aug 2019 (Research Team, 2020)



Figure 7.4. Motorcycle used by delivery service for food (left) and other goods (right) (Research Team, 2020)

7.2. Street Vendors and Hawkers

7.2.1. Street Vendors

Street vendors, in general, occupy space on pavements or side-by, and are often mobile, moving from location to the other to sell their goods. As such, street vendors tend to trigger some major problems in the city, including for pedestrians and vehicular congestion, traffic accidents and other emergency risks (e.g., fire), waste disposal, noise and water pollution, food safety, unfair and poor services, labour violations, and eschewal of official regulations.

Around 80 % of GDP comes from the “informal” sector, which accounts for 95 % of all employees. Street vending is a part of the informal sector, which increases remarkably during periods of economic boom in Cambodia (The Phnom Penh Post, 2019). National Institute of Statistics (NIS, 2013) shows that about 62,780 (3.8%) of the 1,673,390 registered persons are involved in different forms of street businesses. Of these, about 16,419 (1%) are based in Phnom Penh, and 75% are women. The peak influx of street vendors into Phnom Penh was in 1998 when Cambodia’s economy showed negative growth due to the 1997 political crisis, the economic crisis that hit Asia, as well as the conjunction of droughts and floods. A research showed that only 18.7% of the street vendors were born in Phnom Penh while 26.9% were born in Kandal, 9.3%

in Takeo, 9.9% in Svay Rieng, and 9.3% in Prey Veng (Kyodo Kusakabe et al., 2006).

7.2.2. Hawkers

Hawkers are vendors of merchandise that can be easily transported. Hawkers generally sell inexpensive goods, handicrafts, or foods. Hawkers on sidewalks can be seen in several streets in Phnom Penh— operating either in a fixed location or on a mobile stand. Most hawkers generally occupy public space— either a sidewalk or an outer traffic lane-- for their business activities, which in turn slows the general traffic flow.

There are at least three types of hawkers: (1) hawkers that make business from their homes or on their land. These hawkers often have large business activities (e.g., selling goods and services), expanding their business territory into sidewalk space where possible. (2) hawkers that rent space from a landlord to do their business (Figure 7.5 and 7.6). Often, these hawkers rent a small space in front of a landlord’s home—typically the space for sidewalks. Certain hawkers may find a public space near the roadside and pay some fee to designated local persons (e.g., local authority, landlord). And (3) Nomad hawkers that do have any specific locations. They usually do their business from specific vehicles. The location can be anywhere in the city. A hawker may also randomly stop his vehicle and proceed with sales when receiving orders along the way.



Figure 7.5. Hawkers, who own home/land, selling goods (left) and foods (right), Oct 2019 (Research Team, 2020)



Figure 7.6. Hawkers on sidewalks in Phnom Penh, Oct 2019 (Research Team, 2020)



Figure 7.7. Hawkers on vehicles that can go everywhere in the city, Nov 2019 (Research Team, 2020)

7.3. Waste Management

Phnom Penh faces a great waste management challenge following its population growth, per capita income growth, increasing consumption levels, and rapid urbanisation. The waste management system is poor because of improper waste collection and treatment facilities, inadequate technical staff, and unclear responsibilities among staff members. This poor management has led to uncollected rubbish at certain streets, blocking drains and traffic, and causing environmental challenges. The way the rubbish is being transported and loaded using heavy trucks along busy streets has contributed to traffic burdens.

Phnom Penh generates 365,224 tons/year of municipal solid waste, with the per-capita-per-day generation of households in Phnom Penh estimated to be 0.498 kg based on a population of 1,445,902 in 2015 (Seng, 2015). In early 2020, according to the Ministry of

Environment, Phnom Penh generates 3,000 tonnes of rubbish per day, of which 65% is organic waste, and 35% is plastic and solid waste (Khmer Times News, 2020).

The current organization of trash collection starts with disposal on the sidewalks by individuals and businesses. The department of Public Works and Transport (DPWT) is responsible for solid waste management, and a Canadian-Cambodian Joint-Venture, CINTRI (Cambodia) Ltd, established in 2002, is a private company authorized to collect the solid waste from 12 Khans or 96 Sangkats in Phnom Penh. It was reported that about 41% of the total annual waste collected was sent to dumpsites, 11% was recycled, and 48% was burned or thrown away into bodies of water (Fresh News, 2020). The collected waste is transported to Dangkao landfill located in the suburban area about 15.5 km in the southwest from downtown, as illustrated in Figure 8.8. CINTRI organizes its waste collection schedule adapting it specifically to each neighborhood.

Two main transport modes are utilized: garbage trucks and carts (see Figure 7.9). Carts are used to collect garbage in neighborhoods where trucks cannot go. Trucks are connected to GPS and GIS systems. Garbage collecting staff are at high risk during collection and transportation as they lack sufficient protection equipment (see Figure 9.9). Further logistics performance analysis could be useful to improve the garbage collection system and efficiency, however collected garbage data is not available online.

The government has revoked CINTRI's business license in October 2019 (Khmer Times News, 2020). The municipality announced an open public bidding process for national and international companies, with capacity and experience in rubbish and solid waste collection: Phnom Penh would be divided into three zones, and contracts divided between three companies they would be awarded to. In the meantime, the Phnom Penh Municipality is managing garbage collection.



Figure 7.8. Geographical view of Dangkao landfill (Map data ©, Google, Inc.)



Figure 7.9. CINTRI garbage truck (left) and cart (right) (Research Team, 2020)

7.4. Heavy Freight Haulage

Most cargo logistics (more than 90%, figures: JICA-PPUTM, 2014) in Phnom Penh are operated via road transport, mainly by trucks.

These cargo logistics generate extra traffic volume on the city streets, and thus impinge on urban mobility. Based on the cordon line survey by JICA-PPUTM (2014), the annual average estimated inbound and outbound cargo volume by road was 48,500 and 40,400

tonnes per day, respectively. Heavy goods vehicles have been banned in the city. The existing cargo facilities (e.g. dry ports, industrial parks) located along Phnom Penh ring roads have become urban and thus are generating heavy truck traffic. This has posed a challenge in terms of adding an increasing number of trucks in daily urban mixed traffic.

The current modus operandi in Phnom Penh assigns movements of heavy goods vehicles within the city perimeter mainly to night hours for all movements that do not require daytime intervention e.g. for goods reception or processing, loading or unloading. From interviews [2], [7], [16] the research team learned that the primary reason for this regulation (which will be further enforced), is to prevent daytime interference with other road traffic, mainly passenger movements in private cars.

The basic idea of separating freight and passenger movements is actually a very modern one, one that currently resurfaces in leading transportation debates mainly in Europe and North America: Equilibrating the spatial and temporal use of urban space by switching urban cargo logistics to night times is a concept increasingly seen as key for solving obstruction and congestion issues directly related to the steep increase in cargo movements in many cities, mainly triggered by distribution logistics driven by online retailing.

The development of a valid proposal and scenario for future handling of freight in Phnom Penh is facilitated by the rate of adoption of technology as highlighted in interviews [12], [13] and [15]. The development of an urban cargo strategy aligned with the mobility improvement measures as suggested by this report needs to be the subject of a separate study.

Key Takeaways:

- Majority of the urban spaces have been used for private purposes, such as onstreet business activities and privately parked vehicles, which result in inequity of access to urban resources.
- Pedestrianized streets promote non-motorized transport as well as strengthen urban equity in access to urban resources.
- The development of ring roads can connect major mobility corridors and help ease traffic congestion in the city center and encourage more development in the peripheral districts of the city.
- The current modus operandi in Phnom Penh basically assigns movements of heavy goods vehicles within the city parameters mainly to night hours for all movements that do not require daytime intervention e.g. for goods reception or processing, loading or unloading. The objective is to reduce traffic issues in the city.
- Equilibrating the spatial and temporal use of urban space by switching urban cargo logistics to night times could be a key to solving obstruction and congestion issues in Phnom Penh.
- The poor waste management system has aggravated the city environment, especially air and water quality, which affects the quality of life.
- A monopoly in the waste management system did not deliver the best results, so the waste management system should be improved by delegating the tasks and responsibilities to contracted companies.

8. SOCIO-ECONOMIC DEVELOPMENT

Summary:

- The chapter addresses the socio-economic and environmental conditions of Phnom Penh by linking urban mobility to population growth, employment, household income, vehicle ownership, energy consumption and air quality. The challenges of population growth, vehicle ownership, and travel demand for jobs have also been discussed.

Urban mobility is more likely to increase with positive socio-economic development trends. Figure 8.1, based on data collected within the Cambodia Socio-Economic Survey for Phnom Penh, shows the relation of growth in urban population, employment, household income, and vehicle dependency in Phnom Penh between 2007-2017. It reveals that the increases in numbers of population, employment, and household income tend to

correlate with higher vehicle ownership.

Given the assumed dependency, we will consider in the following paragraphs different socio-economic development factors within Phnom Penh such as the evolution of the population, employment situation, and household income to summarily understand their influence on vehicle ownership.

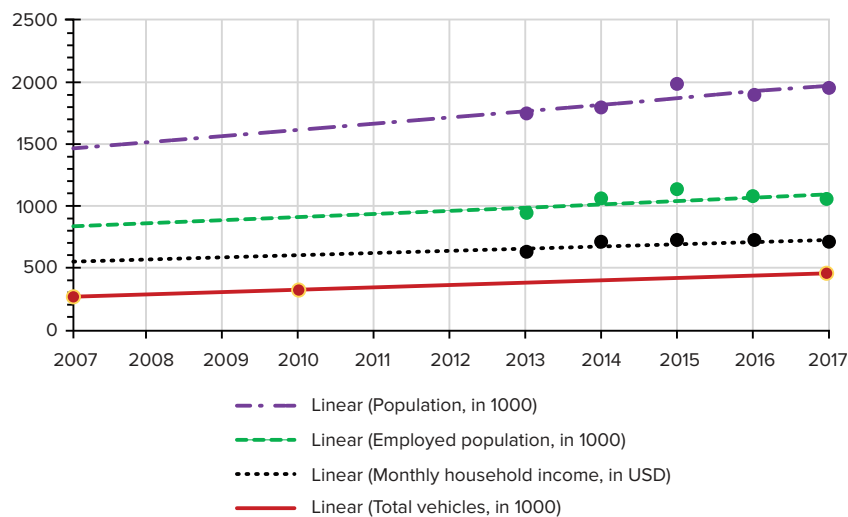


Figure 8.1. Relationship between Socio-economic and vehicle-ownership trends (Source: CSES)

8.1. Population

The population in Phnom Penh is expected to reach approximately 3 million inhabitants by 2035. As people need to travel around

the city, more urban mobility is also expected not only within the city center, but also in the peripheral districts. Traffic congestion, high density of population, and high housing prices in the city centre have pushed people to move

out of the centre to live in the new emerging suburban areas; however, fragile level of basic infrastructure in suburban areas may start posing challenges. A majority of basic services, such as the workplace, healthcare facilities, government services, food supply, and educational institutions are dominantly in the city center and thereby travel demand rate from the suburban areas into the center remains high.

The population grew from 1.5 million to 2.13 million between 2008 and 2019. The annual population growth rates were 2.8% and 3.2% for 1998-2008 and 2008-2019, respectively. Based on the population census 2019 annual growth rate, Phnom Penh population will reach approximately 3 million in 2035, of which 70% will be 15-64 years old (Figure 8.2).

Population moving out of the city centre to live in peripheral districts (Table 8.1, below) represents a clear trend such as between 2011 and 2016. The local population decreased by 23.7%, 21.0%, 18.2% and 12.4% in Chamkar Mon, Daun Penh, 7 Makara, and Tuol Kork districts, respectively. In contrast, the population rates

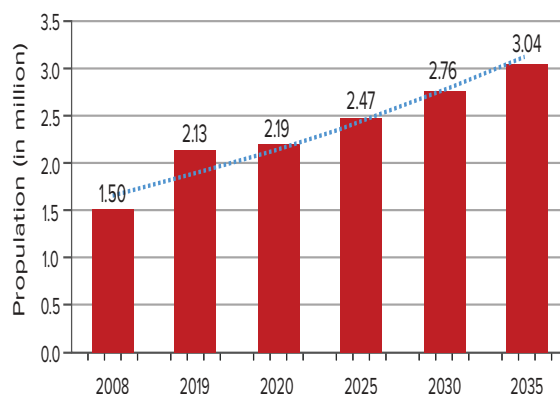


Figure 8.2. Projection of the population in Phnom Penh by 2035 (Source: CSES)

of suburban districts rose at 24.5%, 22.0%, and 20.3% in Sensok, Porsechey, and Dangkor (Phnom Penh extension et mutations, p. 82-87).

The research study team did not include foreign and expatriate population, nor international transient workers, also they may constitute 5-7% of Phnom Penh total urban population, due to the lack of officially available statistics. The team was also not able to break down the Phnom Penh youth population (16-29 years old) percentage due to similar statistical constraints.

Table 8.1. Change of population distribution by district between 2011 and 2016 (Source: Phnom Penh extension et mutations)

District	2011	2013	2015	2016	Change rate
Daun Penh	85,111	126,550	83,861	70,312	-21.0
Chamkar Mon	132,104	182,004	133,947	106,751	-23.7
7 Makara	76,550	91,895	66,127	64,776	-18.2
Tuol Kork	137,797	171,200	133,947	122,568	-12.4
Russey Keo	132,029	13,570	167,173	135,779	2.8
Meanchey	146,627	194,636	172,065	138,743	-5.7
Sensok	105,594	125,536	139,768	139,910	24.5
Porsenchey	159,339	159,455	217,367	20,348	22.0
Chroy Chanvar	63,948	61,214	65,744	62,010	-3.1
Praek Phnov	46,186	47,131	56,254	55,264	16.4
Chbar Ampov	122,143	133,165	134,695	133,064	8.2
Dangkor	76,127	73,287	86,941	95,527	20.3
Phnom Penh	1,283,555	1,379,643	1,457,889	1,329,052	3.4

8.2. Employment

The increase in employment opportunities in Phnom Penh has attracted thousands of migrant workers into the city, and this has resulted in more traffic flow into the city--thus increasing urban mobility. The assumption that most migrant workers are using (when available) facilities provided on their working site or nearby (such as for garment or construction workers) is correct but does not apply for all: About 25,000 people are traveling on a daily basis from neighboring provinces to Phnom Penh through the National Road 4 (NR4), NR 5, NR2, NR6, and NR3. An estimate of 40,000 workers from rural areas are flocking to Phnom Penh for jobs (Phnom Penh City Master Plan 2035, 2015). Labor force (aged 15-64) in the city increased from 1.36 million to 1.42 million between 2013 and 2017 (Table 8.2). Those figures are expected to be much higher considering the informal nature of temporary work, and the limited capacity to survey informal workers. A report from Cambodia Socio-Economic Survey (CSES) indicates that employment by primary industry (i.e., agriculture) decreased about 6,000 between 2013 and 2017 due to a sharp decrease in agricultural land and high demand of land area purposed for real estate development. Employment in the secondary industry (e.g. manufacturing) showed a slight increase of 29,000 between

2013 and 2017. Whereas, the employment by the tertiary sectors increased by 133,000 in the same year. If sectors' employment growth rate remains unchanged, employment in secondary and tertiary sectors may reach 371,000 and 1.12 million people, respectively by 2035. Any increase in employment within these sectors will lead to a proportional increase in travel demand and urban mobility. For example, a number of factory workers migrate to Phnom Penh due to their jobs.

However, an hypothesis proposed by the research team (and that would need further analysis) suggests that migrant workers impact on Phnom Penh Mobility will be very minimal, as the need for them to use--or financial capacity to own--a motorised vehicle is limited (proximity to working places, or transportation means already available e.g. collective trucks dedicated to garment workers). Increasing urban mobility needs are fuelled by "white collars" workers that have relocated in "Borey" or that are living in suburban areas and have overall augmented their travelling distance to work, living at the periphery of the city, as well as international migrants workers and expatriate workers that are for the majority renting service apartment units or houses within city center. Phnom Penh remains the Cambodian city with the largest majority of international workers. Also they do not represent a majority of the total share of Phnom Penh urban population,

Table 8.2. Employment framework of Phnom Penh by year and industry in thousands and percent (Source: CSES)

Phnom Penh	2013		2014		2015		2016		2017	
	No.	%	No.	%	No.	%	No.	%	No.	%
Population	1,738	100	1,794	100	1,993	100	1,897	100	1,948	100
Working age (15-64)	1,273	73.2	1,361	75.9	1,461	73.3	1,374	72.4	1,419	72.8
Employed population	942	73.9	1,059	77.9	1,140	78.2	1,080	78.6	1,065	74.8
Primary	19	2.0	26	2.5	8	0.7	11	1.0	13	1.2
Secondary	238	25.1	299	28.2	328	28.7	281	26.0	267	25.2
Tertiary	687	72.9	734	69.3	804	70.5	789	73.0	781	73.6

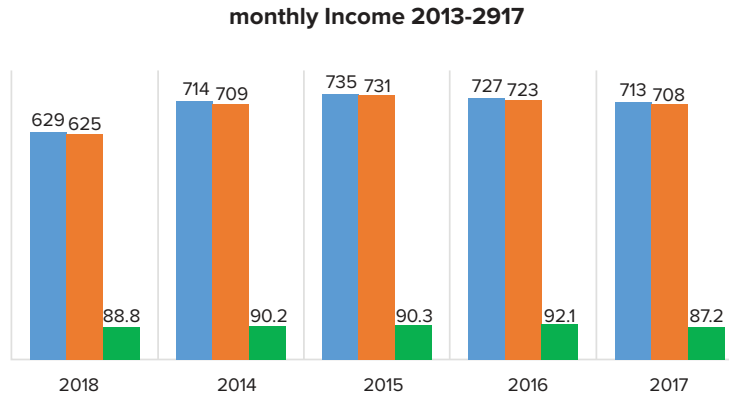


Figure 8.3. Monthly household income (in USD) in Phnom Penh 2013-2017 (Source: CSES)

they dispose of larger income streams and therefore belong to high frequency travellers with a higher propensity for urban movements.

The potential development of electric and renewable energy generated urban transport modes to respond to increasing transport demand can provide an economically viable service to a fringe of the Phnom Penh urban population, while possibly offsetting in the long run carbon emissions derived from intensive use of fossil fuels in the mobility sector. If past attempts to locally produce electric vehicles in Cambodia have not succeeded, new initiatives intend to create the research and knowledge needed in order to build up regulations and attract more responsible investors. Regional start-ups and private groups are in discussion to pilot innovations such as electric charging stations, shared electric vehicles such as motorcycle and cars etc. Local stakeholders such as the National Council for Sustainable Development (NCSD), the Global Green Growth Institute (GGGI), and EnergyLab Asia that are demonstrating an increasing leadership in building up the ecosystem and allow targeted policies to support the development of scalable technologies. When reliability and convenience of proposed electric vehicles services will match price affordability, and possibly get equivalent or lower to the proposed ride-hailing services, it may offer a chance to nudge a larger behavioral change for Cambodian urban vehicle users. Practical operational factors

such as availability of charging stations and travel time-distance to reach, charging time and batteries swap-out, ride user experience and preference of vehicles type.

8.3. Household Income and Expenditure

The total household income in Phnom Penh has increased over the past few years (CSES, 2017). Higher income households are more likely to purchase a new vehicle--and thus increasing urban mobility via private car ownership.

Cambodia has accessed Lower Middle Income Country status, following the World Bank's threshold classification of Gross National Income (between USD 1,026 and USD 4,035). The Phnom Penh economy is a direct contributor to national economic growth and its middle class population income has increased (Figure 8.3). The average disposable income per capita also increased by 12% in 2017 as compared to 2016 but more than 80% of the households increased in debts as outstanding loans from banks or relatives (CSES, 2016).

8.4. Vehicle Ownership

In 2016, the total number of vehicles registered in Phnom Penh reached approximately 2 million, which was already higher than the city's total population of 1.9 million. This trend indicates that citizens are more vehicle-dependent. With

Table 8.3. Vehicle ownership in Phnom Penh between 2007 and 2017 (Source: CSEC 2007, 2010, and 2017)

Vehicle types in PHN	2007	2010	2017	Vehicle changes 2007-2017		
				No.	%	Annual growth
Family car	33,352	42,938	72,894	39,542	118.56	11.9
Minibus	1,348	1,383	1,631	283	20.99	2.1
Bus	537	233	458	-79	-14.71	-1.5
Light truck	2,573	2,877	2,960	387	15.04	1.5
Heavy truck	1,077	1215	1395	318	29.53	3.0
Tricycle	1,151	1,877	7,735	6,584	572.02	57.2
Motorcycle	162,846	196,529	303,658	140,812	86.47	8.6
Bicycle	63,546	76,082	73,817	10,271	16.16	1.6
Others	1,205	2352	673	-532	-44.15	-4.4
Total	267,635	325,486	465,221	197,586	73.83	7.4

inadequate mass transit services in Phnom Penh, the trend also suggests a higher share of vehicle-dependency in urban mobility.

Based on the CSES data, the number of vehicle owners in Phnom Penh increased roughly by 7.4% annually from 267,635 units in 2007 to 465,221 units in 2017 (Table 8.3). The numbers of tricycles, family cars, and motorcycles rose unexpectedly. The three types of vehicles increased by more than 500%, 100%, and 86%, respectively, over the past ten years (2007-2017).

8.5. Environmental Conditions Related to Rapid Urban Development in Phnom Penh

8.5.1. Mobility and Air Pollution Considerations

Phnom Penh has no central incineration plant for solid and hazardous wastes, and mixed-solid wastes that are commonly burned in open areas. Johnsen and Munford (2012) also speculated that motor vehicles and older generators are the predominant sources of air pollution (ibid). Exhaust emissions and

road dust re-suspension lead to an increasing amount of suspended particulates, thereby provoking respiratory diseases known as the major causes of morbidity (ibid).

Adding to this, air quality related data is currently not reliable (available up-to-date data does not hold statistical significance yet, as available only through a very limited number of official sources or using proxy such as privately owned sensor devices), thus not yet available to comprehensively build structural improvements through a technical and legislative process. Furthermore, the low carbon and atmospheric pollutants emission scenario analysis for household, industry, and transportation has not been carried out to the required extent.

The Ministry of Environment (MOE) releases a regulation related to vehicular emission standards for emission rates by vehicle class as listed in Table 8.4 below. However, this regulation only imposes emission rates for carbon monoxide (CO) and hydrocarbon (HC), while nitrogen oxides (NO_x), sulphur dioxide (SO₂), and particulate matters (PM_x) are not yet considered. Also, this currently existing legislation is not firmly enforced. Furthermore,

Table 8.4. Emission rates by vehicle classifications (Source: Adopted from the Sub-degree on Air Pollution Control and Noise Disturbance, 2000)

No.	Vehicle Type Vehicle age	Fuel Type	Emission Rate				
			CO (%)		HC (ppm)		Black Smoke (%)
			>= 5 years	< 5 years	>= 5 years	< 5 years	
1	Two-stroke motor vehicle	Gasoline	4.5	4	10,000	3,000	
2	Four-stroke motor vehicle	Gasoline	4.5	4	10,000	2,400	
3	All vehicle types	Gasoline	4.5	4	1,200	800	
4	All vehicle types	Diesel					50

vehicle sizes (e.g., small, medium, and large) and types (e.g., three-wheel vehicle, two-wheel vehicle with carriage, hatchback, sedan, SUV, and CUV) are not categorized by emission rate standards. Until now, the MOE has no plan to set up mobile emission standards equivalent to the European emission standards as enacted in EU 2018/858. Thus, car-based transportation emerges as one of the serious sources of pollution in Phnom Penh. An estimation of future healthcare costs triggered cannot be undertaken within the framework of this report and needs to be the subject of a separate investigation.

The potential development of electric and renewable energy generated urban transport modes to respond to increasing transport demand can provide an economically viable service to a fringe of the Phnom Penh urban population, while possibly offsetting in the long run carbon emissions derived from intensive use of fossils fuels in the mobility sector. If past attempts to locally produce electric vehicles in Cambodia have not succeeded, new initiatives intend to create the research and knowledge needed in order to build up regulations and attract more responsible investors. Regional start-ups and private groups are in discussion to pilot innovations such as electric charging stations, shared electric vehicles such as motorcycle and cars etc. Local stakeholders such as the National Council for Sustainable Development (NCSD), the Global Green Growth

Institute (GGGI), and EnergyLab Asia that are demonstrating an increasing leadership in building up the ecosystem and allow targeted policies to support the development of scalable technologies. When reliability and convenience of proposed electric vehicles services will match price affordability, and possibly get equivalent or lower to the proposed ride-hailing services, it may offer a chance to nudge a larger behavioral change for Cambodian urban vehicle users. Practical operational factors such as availability of charging stations and travel time-distance to reach, charging time and batteries swap-out, ride user experience and preference of vehicles type.

8.5.2. Energy Demand and CO₂ Emissions

This section considers the key elements of environmental impacts (i.e., CO₂ emission) and energy consumption due to an increase in the number of registered vehicles in Phnom Penh (i.e., motorcycle and car): Depending on the evolution of global energy markets, especially those for mineral oil derivatives, transportation and mobility cost hikes will translate into higher cost to the local economy.

The following assumptions are made to estimate the energy demand and CO₂ emissions in Phnom Penh: (1) The average vehicle kilometer travelled of motorcycles and cars is assumed to be approximately 1,000

km per month.(2) The load factors of 1.5 and 2.8 persons are assumed for motorcycles and cars, respectively. (3) The fuel consumption rates were 0.025 l/km-vehicle for motorcycles (Ahanchian and Biona, 2014) and 0.107 l/km-vehicle for cars (Rith et al., 2018). (4) The energy density is assumed to be 34.2 MJ/l and 36.4 MJ/l for motorcycles and cars, respectively. (5) The emission factor (energy heat) for CO₂ emission is assumed to be 74.1 tonnes/TJ for motorcycles or cars.

Energy demand

The implications of oil and gas markets on secondary costs of mobility in Phnom Penh are also highlighted by the following projection: As annual energy demand is expected to increase with the number of registered vehicles, Figure 8.5. shows the estimated evolution of energy demand for Phnom Penh. The energy consumption will increase from 0.75 x 10¹⁰ MJ/year and 0.88 x 10¹⁰ MJ/year in 2010 to 3.28 x 10¹⁰ MJ/year and 3.64 x 10¹⁰ MJ/year in 2035 for motorcycles and cars, respectively. This is equivalent to an increasing rate of approximately 85% from 2020 to 2035, under the assumption of no governmental policy intervention (e.g., vehicle growth control, alternative public transport modes such as—largely electrified—public buses or an urban rail-based mass transit system).

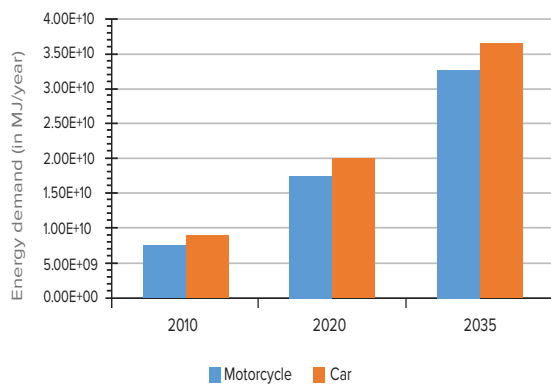


Figure 8.5. Projection of annual energy demand for motorcycles and cars in Phnom Penh (Research Team, 2020)

CO₂ emissions

The projected trend of CO₂ emissions shows an increase from 12.06x10⁴ tonnes/year in 2010 to 51.24x10⁶ tonnes/year in 2035 (Figure 8.6.).

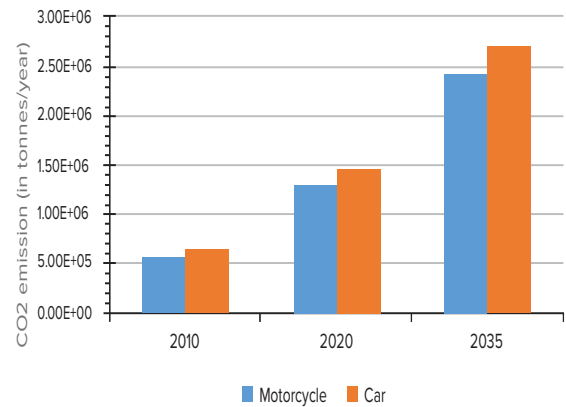


Figure 8.6. Projection of annual CO₂ emission for motorcycles and cars in Phnom Penh (Research Team, 2020)

With expectable extensions of mandatory regional emissions trading as a consequence of the ongoing and globally increasing efforts for climate protection, this rise in CO₂ emissions will result in a considerable cost factor directly related to and inseparable from an ongoing predominance of non-decarbonized transportation. While the nature of such costs (internal or external with regard to transportation) is a matter of definitions and methodologies applied, they cannot be estimated within the framework of this study. It is obvious, though, that they directly affect cost structures both for the local economy as well as for individual citizens.

8.5.3. Acoustic and Static Pollution

Noise pollution, and also vibration, are emerging concerns in Phnom Penh. However, the Department of Environment does currently not compile any data on noise pollution and vibration, even though accumulated and monitoring data are indispensable for current situation analysis and forecasting. Obviously,

noise pollution and vibration do become worse owing to the observed, exponential increase in the number of private vehicles (i.e., motorcycles and passenger cars), and absence of control and regulations on modified vehicle equipment such as gas exhaust or horns customization.

8.6 Gender mobility considerations

No recent demographic data exists on gender related statistics of male and female distribution in Phnom Penh. Based on one of the latest reports produced in 2018 by the National Institute of Statistics (WOMEN AND MEN in Cambodia FACTS AND FIGURES 2018, Ministry of Planning Phnom Penh, Cambodia), the national figures given for urban gender parity are quite stable, indicating almost an equal distribution from 2008 till 2016. A more precise age, occupation, income/asset distribution specific to Phnom Penh would be needed to assess specific gender related vulnerabilities.

The lack of research-based gender-disaggregated data limits the understanding of gendered aspects of urban mobility and the capacity to design or adapt relevant mobility policies for increased gender equality.

Knowledge and technical possibilities based on meta data analysis generated by large private ride hailing company customers mobile generated information such as Grab, PassApp and other would be possible to highlight gender gaps in mobility, and reported issues and risks that would touch upon safety and security. The same reasoning would also be valid if we want to measure inclusiveness and access associated with low income users.

Phnom Penh has recently been paying more attention to the specific needs and vulnerabilities of girls, women and LGBTQ+ populations. Phnom Penh Municipality, the Private Sector, and international development agencies have been conducting a series of rapid research. They piloted project responses to allow vulnerable groups access to new services to increase safety and security issues such as mobile phone alert or real-time tracking systems. All actors also have an increased awareness of the specific needs a woman or a man have and the different mobility experience you get depending on your gender. The risk of sexual abuse or physical violence, and the latent insecurity at different time of the day restricts travels and use of specific transport modes.

Key Takeaways:

- The increasing trends of population, employment, and income have led to a higher demand for urban mobility in Phnom Penh.
- The number of registered vehicles in the city has increased by 7.4% annually between 2007 and 2017. More than 80% of the vehicles are second-hand imported vehicles. This also leads to an increase in the energy demand and air pollution (e.g., CO2 emission).
- To reduce CO2 emission, policy (e.g., restriction on importing and tax leveraging for second hand vehicles should be considered).
- To reduce both energy demand and air pollution, promotion of urban public transport services could be a better alternative solution.

9. ROAD SAFETY

Summary:

This chapter focuses on the road safety relevant issues, including the current situation, the response by authorities, and possible actions.

9.1. Road Crash and Victim Information System

In Cambodia, Road Crash and Victim Information System (RCVIS) has served as a critical tool for assessing the burden of road safety, targeting policy responses, and evaluating the effectiveness of road safety interventions. RCVIS has been implemented since 2004 by the Ministry of Public Works and Transport, Ministry of Interior, and Ministry of Health, with the technical and financial support for Handicap International (HI). RCVIS provides road safety stakeholders with accurate, continuous and comprehensive information. Road crash data has been collected from two sources: the traffic police unit and health facilities (hospitals and health centers). Most road crash data has come from the traffic police, as not all hospitals and health centers were not able to record such crashes because many health facilities are located in remote areas, with limited human resources and equipment.

From 2010, RCVIS has been managed and the General Secretariat of the National Road Safety Committee (NRSC), with support from HI. NRSC releases a summary report about road crashes and casualties in Cambodia annually (NRSC, 2018). The latest fact figures about road safety in Cambodia show at least 5 fatalities resulting from traffic accidents every day; more than 70% of road fatalities are motorcyclists; 45% of road fatalities aged 15-29; 90% of traffic accidents were caused by human factors; more than 10%

of road fatalities involve drunk driving; more than 70% of road fatalities among motorcyclists did not wear a helmet; 40% of road fatalities involve over-speeding.

9.2. Current Situation

Figure 9.1 shows the road fatality trend in Phnom Penh, in comparison to that in Cambodia. According to NRSC (2018), there were approximately 3,700 road traffic accidents in 2017, resulting in about 13,300 casualties. Among the casualties, about 4,850 were with serious injuries and 1,976 fatalities. Compared to 2016, the number of fatalities increased by 7%, while the serious injuries increased by 4%. Further, the highest number of road fatalities occurred in Phnom Penh—i.e., there were 213 deaths, which is equivalent to 11% of the nationwide toll in 2017.

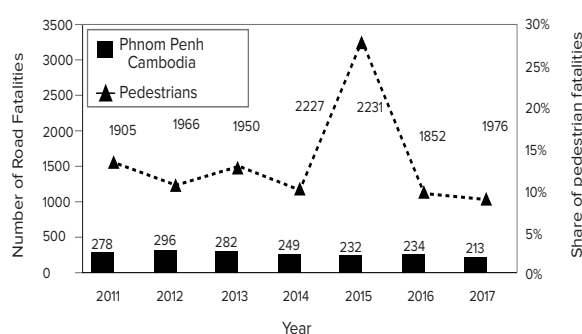


Figure 9.1. Number of road fatalities in Phnom Penh and Cambodia 2011-2017 (Source: NRSC)

On the other hand, the road fatalities among pedestrians appear to have higher values

for Phnom Penh than in other Cambodian provinces. For example, it was reported that the share of pedestrian fatalities was 9% in Phnom Penh in 2015, making this in the 2nd rank, after Battambang province. In 2016, this share (8%) in Phnom Penh ranked at the top. This implies that it is necessary to have proper pedestrian infrastructures that would lower the fatality rate among pedestrians in Phnom Penh. The cost of road safety in Cambodia by NRSC was reported to be approximately USD 1.2 million (excluding other budgets supported by Cambodian government on road safety, about 52%).

9.3. Response by Authorities

9.3.1. Traffic Police

The governments rely heavily on traffic law enforcement programs to modify driver behavior and enhance road safety. In general, two related functions of traffic law enforcement, apprehension, and deterrence, have been implemented through three processes: (1) the establishment of traffic laws, (2) the policing of those laws, and (3) the application of penalties and sanctions to offenders. A key implementer of these processes is the traffic police whose roles are to provide at least 10 effective interventions, including enforcement of laws and legislations, educational programs, seat belt and helmet wearing enforcement for road users, enforcement of Antilock Braking System (ABS), drivers' penalty enforcement, pupil liaisons' education, provisional driver licensing, road bumps and traffic improvement plans.

Therefore, the roles of traffic police in intervening in traffic congestion and accidents are of great importance. This section briefly addresses the roles of Phnom Penh traffic police in enforcing traffic law. Cambodia's traffic law has been amended a few times over the past ten years in order to meet the current traffic

situation. On May 1st, 2020, a sub-degree to increase fines and penalties (about five times higher) for traffic violations was enacted. About 4,000 police forces including 3,507 traffic police officers and 364 vehicles were declared to be used in the operations to impose the new fines. In the first three days of enforcement, the police checked more than 8,000 vehicles – about 6,000 motorcycles and 2,000 cars.

According to an interview with the Head of the Phnom Penh Traffic Police, the traffic police have been strictly implementing and practicing traffic law and other related legislation so as to ensure road safety for all road users. In addition to the legal enforcement, the traffic police also have joined various educational programs, such as on radio and TV programs, to disseminate the current traffic situation as well as to educate people about traffic law and preventive measures. Moreover, the traffic police also collaborate with educational institutions, including public and private schools and universities to jointly educate and implement the traffic law. Despite tremendous efforts in enforcing the laws, the traffic police are facing some challenges, such as an increase in private vehicles, population growth, incompetent officers, insufficient traffic infrastructure, technology adoption, and lack of public involvement. Therefore, financial and technical assistance to strengthen the capacity of traffic police officers in terms of legal practices and enforcement is a necessity. Meanwhile, the investment in traffic infrastructure, such as street surveillance cameras, traffic monitoring systems, and road safety facilities will reduce the extreme workload of the traffic police who currently apply the labor-intensive approach. But those technical systems merely serve today in assisting data collection efforts, and for the time being can not substitute efficient manpower capacity to regulate and fluidify traffic at critical road junctions, and that can also enforce the law and regulate a large diversity of subpar driving behaviors.

9.3.2. National Road Safety Committee (NRSC)

National Road Safety Committee (NRSC) is a national body working closely with the Ministry of Public Works and Transport, Ministry of Interior, and Ministry of Health to propose laws, policies, and preventive measures that could tackle traffic accidents in Cambodia. Moreover, with technical and financial support from Handicap International, the NRSC has developed Road Crash and Victim Information System (RCVIS) to provide accurate, continuous, and comprehensive information and data for policy development, action plan, and evaluation of the impact of road safety initiatives.

Despite the remarkable achievements in recording traffic data for road crashes and victims' information, open access to traffic data widely remains a barrier for researchers and other users. Also, the road crash and victim datasets are not fully completed. For example, the location of the accident (latitude and longitude address), real-time accidents, types of vehicles, victims' information, and the reasons for crashes are not accurately recorded. The accurate and complete traffic datasets will help researchers and experts to analyze and determine the blackspots and causes of accidents which will be helpful for policy intervention. Therefore, it is essential for NRSC to develop a database system that can store traffic data. At the same time, the data should be publicly accessible to encourage research and debate on the issues of traffic accidents and safety-related measures aligning with the Cambodian context.

9.3.3. Emergency Response

Regarding the emergency response services, it was reported that about 16% of the road casualties were fatalities and other 39% were

severely injured (NRSC, 2018). Approximately 75% of the victims of road fatalities died immediately at the accident sites, 19% died at hospital, and 6% died on the way to a health center. Majority of the casualties (75%) were transferred by private transport, while the remaining 25% were transferred by an ambulance. Figure 9.2 shows the duration that is required to transport the victims of road accidents to a health center in Phnom Penh and in other provinces. Majority of road casualties were transferred to a health center in Phnom Penh (78%) and in other provinces (65%), after one hour after crashes. This implies that emergency response via ambulance services should be improved, so that transfer time to a health center after an accident would be shorter, and more lives could be saved.

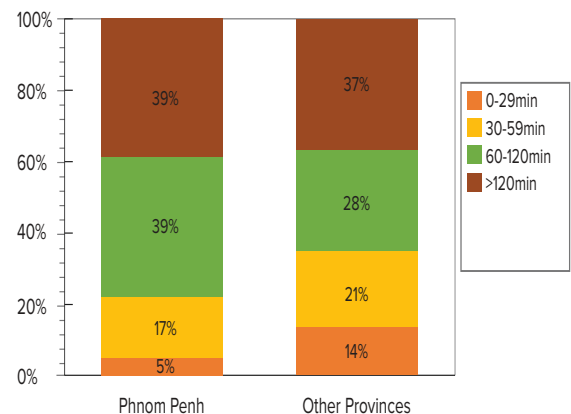


Figure 9.2. The duration for transferring road casualties to a health center in Phnom Penh and in other provinces (NRSC, 2018)

Figure 9.3. shows the rate of casualties in Phnom Penh by different time of the day. The higher rate of road casualty occurred in the evening time, between 18:00 and 22:00, from 4% to 9%. During the year, higher rates of road fatalities were also observed in January (11%), April (11%), and December (9%). These months cover national holidays (e.g., Chinese and Khmer New Year), during which a lot of people travel on roads.

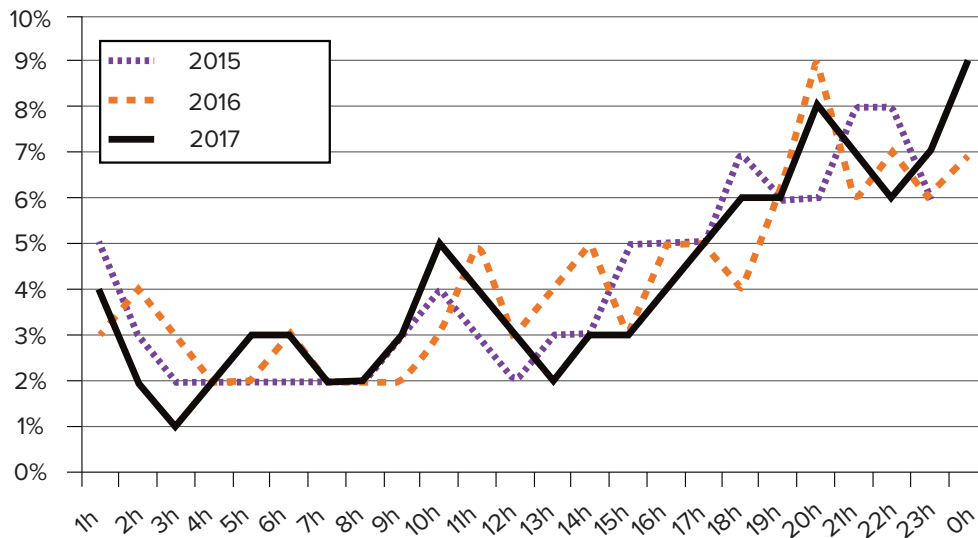


Figure 9.3. Time of day that the road crashes occurred in Phnom Penh (NRSC, 2018)

9.4. Insights from UNDP Research

Based on data for the 2014-2017 period, Marshall and Runsinarith (2019) had a more detailed look into the causes and the economic costs of road traffic accidents in Cambodia. Based on “prudent assumptions”, they found an overall cost of USD 418 m for 2016, roughly 2.1 % of the Cambodian GDP, which is very high in an international comparison. Fatality costs were found to represent 83% of the total costs.

9.5. Suggested Actions

Marshall and Phim found conduct in road traffic to be a major driver of economic costing of road traffic accidents, followed by non-wearing of helmets or seat belts, drinking, speeding and using mobile phones. As a consequence, their policy recommendations include focused action on reducing fatalities, addressing the above-mentioned findings with highest priority. Another focus should be on the improvement of road infrastructure, including street lighting. The research points out that investments in improving conduct and road conditions leads to direct economic pay-offs alongside the human ones.

Key Takeaways:

- The Road Crash and Victim Information System (RCVIS) has been established to collect more reliable road crash data in Cambodia since 2004.
- The National Road Safety Committee (NRSC) publishes a summary report about road crashes and casualties in Cambodia annually.
- For Policy Recommendations, see Marshall and Runsinarith (UNDP 2019)

10. INSIGHTS FROM PHNOM PENH TRANSPORT SYSTEM STAKEHOLDERS

Summary:

This chapter examines the viewpoints from experts and relevant stakeholders, whose jobs currently involve urban mobility and development of Phnom Penh, via a series of interviews. The interviewees with various professional backgrounds and insights (e.g., government officials, researchers, business owners, and development agencies) were interviewed face-to-face, to identify the current urban issues as well as their future consideration regarding the challenges and possible solutions. Their responses were hierarchically analyzed.

10.1. Scope of Interviewees

Motivation

A key part of this work is a structured collection of inputs from core stakeholders of urban mobility in Phnom Penh: The objectives were to learn in which fields the different stakeholders, from their professional backgrounds and insights, identify the issues to be addressed that they consider to be of core importance in the current situation and layout of Phnom Penh, as well as to identify where and to what extent their observations overlap, which can be seen as a proxy for the urgencies identified.

In response to the objectives as outlined in chapter 3.1., interviews have been conducted with 22 key stakeholders and experts with regard to the development of Phnom Penh's urban and transport system. The approach chosen as well as a graphic representation of the summary of the results (see Table 15.2.) are detailed in Annex 15.

Categorization

The results from interview transcripts have been categorized into sets of criteria wide enough to serve as reference points between interviews, despite unavoidable areas of overlap.

These criteria then again have been classified into 5 categories, the colours referring to Table 15.2. in Annex 15:

Category 1: Road Traffic Related Issues (blue background)

Category 2: Societal Issues (red background)

Category 3: Transportation Offer and Infrastructure Related Issues (yellow background)

Category 4: Urban Planning Issues (green background)

Category 5: Public Policy and Planning Issues (dark grey background)

10.2. Hierarchy of Perceived Problems

Summary of Findings: Key Areas of Concern as Identified by Stakeholders

Ranked by importance of appearance in the 22 stakeholder interviews conducted by the research team, the following topics, grouped by similarity, have been identified as prevailing:

Rank 1—mentioned 12 times:

- Misalignment between road construction and residential development, lack of Transit-Oriented Development TOD: **Category 4**

Rank 2—mentioned 10 times:

- Poor development of public transportation: **Category 2**
- Inefficiency of Zoning Laws and lack of Enforcement of Land Use rules: **Category 5**

Rank 3—mentioned 9 times: • Non-enforcement of existing traffic laws: **Category 1**

- Existence of too many master plans that overlap but are not followed: **Category 5**

Rank 4—mentioned 8 times:

- Safety deficits of second-hand imported vehicles: **Category 1**
- Non-availability of rail-based mass transit: **Category 3**

Rank 5—mentioned 7 times:

- Lack of Walkability: **Category 4**
- Lack of understanding of the “public good”: **Category 2**
- Normativity of a perceived middle-class lifestyle: **Category 2**
- Effects of Land Speculation: **Category 5**

Generalized Takeaways

It is noted that all 5 categories are represented more or less equally (2 nominations for Cat. 1 thru 4, 3 nominations for Cat. 5). This yields two core takeaways:

(1) In a holistic assessment carried by major system stakeholders, all categories are perceived as having to be addressed with comparable importance.

(2) A functional and political linkage and interdependency between the categories exists, which cannot be targeted and handled in an isolated manner, but only jointly in a multi-disciplinary approach.

10.3. Deductions for the Estimation of External Costs of Transportation in Phnom Penh

The interviews with stakeholders and the picture they give in terms of areas of concern are a cornerstone of the research undertaken by the research team. Thus, it is crucial to identify to what extent these insights coincide with the base for the cost calculation approach as developed by the research team and laid out in chapters 11.2 and 11.3.: Since no standard methodology for calculating the external costs of urban transport externalities exists (see chapter 11.1. for a brief discussion), the research team based its approach on both the analysis of the status quo in Phnom Penh, as mainly described in chapters 6 to 8, as well as the expression of priorities as identified in and deducted from the interviews.

As laid out in chapter 11.2., the estimation of external costs of transportation in Phnom Penh in the model developed here is a sum of several key factors (compare box C in chapter 11.2). Though no sharp delimitation is possible and factors largely overlap and cross-

condition, Table 10.1. below depicts how these factors basically coincide and overlap with the main categories of concern found from the stakeholder interviews. While not exhaustive,

all areas of concern raised by stakeholders are reflected in the cost of transportation externalities:

Table 10.1. Correlation and Overlap between categories of concern from stakeholder interviews and key cost factors (Research Team, 2020)

COST FACTOR	CORRELATED AREA OF CONCERN	CATEGORY
Congestions Costs	Road Traffic Related Issues Public Policy and Planning Issues Transportation Offer and Infrastructure Issues Urban Planning Issues	Category 1 Category 5 Category 3 Category 4
Passenger Vehicle Productivity Losses	Transportation Offer and Infrastructure Issues Urban Planning Issues	Category 3 Category 4
Road Accident Costs	Road Traffic Related Issues	Category 1
Noise and Pollution Costs	Societal Issues Road Traffic Related Issues	Category 2 Category 1
Loss of Urban Potential	Urban Planning Issues Public Policy and Planning Issues	Category 4 Category 5
Hindering of Sustainable Modes	Transportation Offer and Infrastructure Issues	Category 3

Key Takeaways:

The interviews with stakeholders yield two core takeaways:

- In a holistic assessment carried by major system stakeholders, all categories are perceived as having to be addressed with comparable importance.
- A functional and political linkage and interdependency between the categories exists, which cannot be targeted and handled in an isolated manner, but only jointly in a multi-disciplinary approach.

11. COST ESTIMATION OF TRANSPORT EXTERNALITIES

Summary:

This chapter investigates the externality costs relevant to urban mobility. It highlights a set of key transport externalities elements that carries an important weight, and proposes the calculation of associated external costs which characterize the current urban transport situation in Phnom Penh. From combined observations, measurements, international comparisons and third-party information, the different components to add up to an estimated total yearly cost of the transport externalities were also predicted based on certain assumptions.

11.1. General Remarks on Cost Estimation

Comments on Literature and Expert Discussion

Urban transport is at the heart of urban life, and largely preconditions the development of cities. Surprisingly enough, no unified, established procedure or model exists for calculating the external costs of urban transport as a whole or by modes. Given the tremendous impact of transportation on long-term social and economic development, overall sustainability and current societal discussions on climate change, this might appear as surprising.

However, due to the broad set of factors influencing the role and the evolution of urban transport, and reciprocally the key effects of urban transportation on cities, the task is more complex than it might appear at first sight. While some widely cited studies such as the “Urban Mobility Report (UMR)” (USDOT, 2013) exist, these are largely focused on specific U.S. contexts, making them hardly transferable to contexts such as Phnom Penh. Also, as Litman (2019) in his “Congestion Costing Critique” finds, the UMR has strong methodological weaknesses even if applied to a U.S. context,

including that it “[...] exaggerates fuel savings and emissions reductions, ignores generated traffic, and does not consider other planning goals [...] Much of its estimated congestions costs consist of speed compliance [...]” (ibid).

This critique—of a key piece of literature, developed by leading experts—is symptomatic for the field: Relatively simple, universally ‘portable’ and robust econometric models that could be applied to different contexts, developed and developing, do not exist, and those that cover sub-aspects still require extensive handling of large volumes of data. Specifically considering the cost of congestion, a good overview is given by Litman (2019-2). Also this literature review reveals that a thorough quantitative analysis of the external costs of urban transport can probably only be achieved through a complex modeling, using agent-based tools such as MATSim.

Role and Scope

As mentioned in chapters 2 and 3, our approach does not follow a detailed statistical analysis based on datasets and mathematical modeling, but chooses an approach based on site analysis, interviews with system stakeholders, with identification of their priorities, and deductive

analytics, complemented by third-party data sources. The goal is to identify core factors influencing the external cost of urban transport in Phnom Penh, and advance representative, sizable figures.

Procedural Remark: Representation in Costs per Citizen

In the interest of a straight forward, manageable and expandable approach that is focused on reflecting orders of magnitude, a breakdown of cost on a per-person level will be undertaken. This representation has several advantages: It allows

- to align the various components of the external costs of urban transportation in Phnom Penh along a unified, intuitive metric
- to work with limited data available and estimate sizes without creating a false illusion of precision
- to easily add or change parameters or redistribute groups of citizens e.g. per income or to alter the granularity of the representation (e.g. divide cohorts up in more sub-groups by income)
- the possibility to easily change values of variables when new insights become available (more precise information e.g. on income distribution) or if values change significantly (e.g. raising salaries plus resulting

shifts between income group populations)

11.2. Composition and Structure of External Costs of Urban Transport In Phnom Penh

To keep the reflections understandable and transparent and to provide a base for future work, the approach chosen in this report is to consider the total cost of urban transportation externalities in Phnom Penh as a sum of costs covering different fields: This is a focus on key elements that the research team identified as core for cost estimation, without either duplicating existing work or incorrectly applying templates created for a different context.

Graphical Overview

As mentioned in chapter 10.3., no strict delimitation between the different areas is possible since they do overlap and cross-condition themselves to some extent. Still, in a first approximation, it appears not unreasonable to choose the factors below as adding up to what can be considered a full cost view. The systematic considerations from Box B will be used for those in Box A, and finally become part of the estimation as per Box C, with final considerations as per Box P.

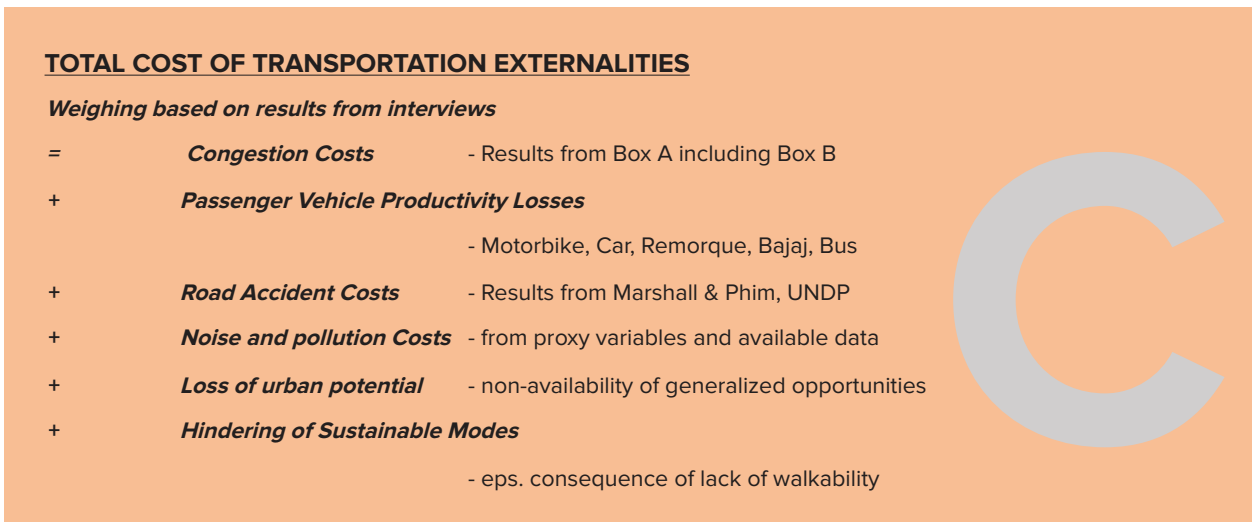


Figure 11.1. Cost Composition —Total Cost of Transport Externalities (Research Team, 2020)

TIME LOSS	= excess travel time for trips in comparison to free-flowing traffic
3 components:	
• Work Travel	= cost saving approach (to employer or self-employed)
	- Labour market and wage category
	- value of reliability
Non-Work Travel	= marginal value of time associated to travelling (leisure, family)
	- based on 25-40% of work time
	- value of reliability
• Freight / Cargo	= cost-savings (negative or positive)
	- driver wages
	- difference in vehicle usage costs
	- value of reliability



Figure 11.2. Components of Time Loss (Research Team, 2020)

Considerations on sub-structures of these factors will follow in sub-chapters as follows:

- 11.3.: Cost of Time
- 11.4.: Cost of Congestion
- 11.5.: Unrealized Urban Economic Potential
- 11.6.: Vehicle Productivity Losses
- 11.7.: Negative Impact on Sustainable Transport Modes (Hinderings)
- 11.8.: Other Costs (Road Accident Costs, Noise and Pollution Costs, etc.)

As explained above in chapter 10.4., the categories identified as critical by stakeholders of urban transport in Phnom Penh are covered by this approach.

11.3. Cost of Time

The cost of time in the context of urban transport will be represented as cost resulting from delays relative to an ideal, unhindered transport from origin to destination (differential approach). This is the way that costs of time will not only target the population (cost per individual), but also the economy (mainly from delays in freight deliveries).

The cost of time has several components, summarized in the following graphic:

Graphical Overview

While these categories have no sharp delimitations between them and partly overlap, consequences of delays are difficult to factor in terms of external cost, since they are highly dependent on the economic conditions of an individual and the specific nature of a (delayed) trip.

11.3.1. Work Travel

Work travel is considered as a citizen’s travel between home and work site: If the work site is generally in the same, geographically close place, such as an office for employees, and the travel to the site occurs on a regular basis, it is generally referred to as “commuting”.

11.3.2. Non-Work Travel

Non-work travel is all other travel than work travel, including

- Social travel (related e.g. to visiting family and friends)
- Organizational travel (related e.g. to official duties and running errands)
- Leisure-related travel (including shopping, recreational activities)

In a first-order approach as the one undertaken here, they will be taken into account with 25% of work-travel based values.

11.3.3. Commercial Transportation (Freight and Cargo)

- Delays of deliveries (material for industrial processing and deliverables): While these depend on multiple factors too complex to estimate, a consideration on GDP levels can provide an illustrative figure: A report for Great Britain (Arcadis, 2016) considered the direct economic cost of delays resulting from a lack of investment into transport infrastructure to be the equivalent of USD 60,000 per minute to the British Economy (based on a 2018 UK GDP of 2855 bn). Assuming, in a first approximation, an underlying linearity of factors, and with limitations of the analogy and transfer, an equivalent calculation would give a cost estimate of roughly USD 500 per minute to the Cambodian Economy.

11.4. Cost of Congestion

As mentioned in the introduction to chapter 11, surprisingly enough and in stark contrast to the global importance of the cost of congestion for urban transport, not only there is no exact method, but also no standard methodologies exist.

A good representation – and a unique resume—of the different approaches is compiled in Grant-Muller and Laird (2006). One of the concluding insights is that “with respect to breaking the link between transport and economic growth (“decoupling”), there is strong empirical evidence that growth in travel is related to income, the cost of travel and the ‘need to travel’ [...], the underlying relationships are however, complex and further understanding of the demand for travel is needed before drawing firmer conclusions on the links between transport and the economy.”

Grant-Muller and Laird’s conclusion yields that the closest way to get some insights would be an advanced model of the whole city of Phnom Penh, using e.g. an agent-based simulation tool. As mentioned earlier, since this would be, in itself, an investment going far beyond the scope of this report, the team has chosen a different approach:

Graphical Overview

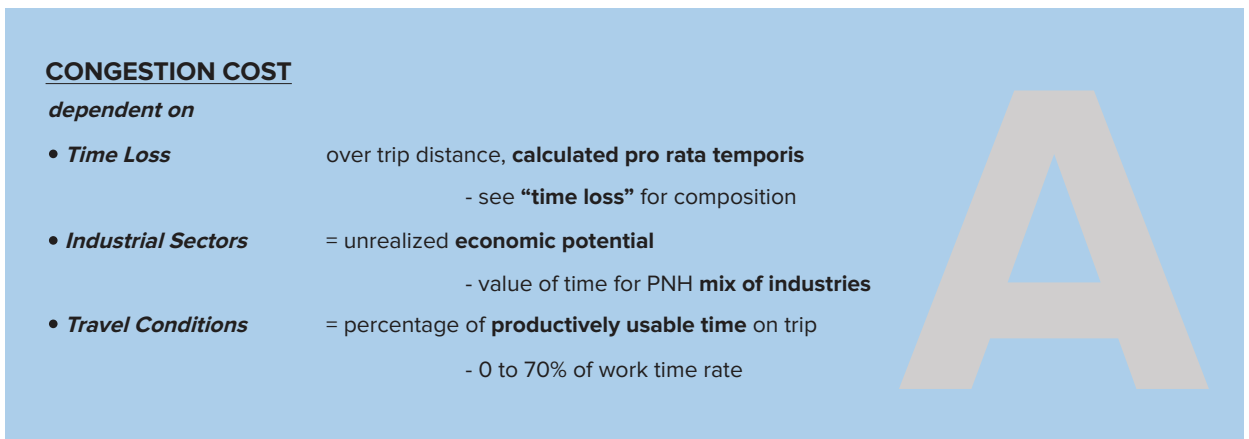


Figure 11.3. Cost of Congestion (Research Team, 2020)

11.4.1. Time Loss

The time loss as calculated as per chapter 11.3. is conceived by segment of population and needs to be multiplied by trip length (see chapter 11.9. for a compilation).

11.4.2. Negative Costs of Time

Costs in the sense incurred here are, by concept, a negative factor. However, the numeric value of cost is an arithmetically positive value.

In transportation, novel concepts such as “screen time” have recently been introduced to the social perception and use pattern analysis (Mota et al., 2009): in a generalized form, such concepts refer to the capacity to make the best possible use of a travellers’ “productive” time while on transportation: While on a public bus, a user might make leisurely or professional use of his personal screen such as phone or tablet, and on board a comfortable, air-conditioned commuter train might even be able to do productive work on his laptop, time driving a car will be rather less productive, depending on the nature of personal onboard conversations and telephone calls via handsfree speaker system as the only non-transport related productivity options, and will be heading towards zero e.g. when driving a motorcycle. It is notable that the latter options are discounted by legal requirements and implications, e.g. a telephone call made while driving that may be legal per se might be used against the driver in case of an accident.

Also, work on a bus will in most cases still not imply the same level of productivity as in an office, and for a bus rider the quality resulting from interactions with their phone screen will differ depending on conditions of the specific trip, e.g. standing or seated.

As a consequence and in an overall assumption, and in a consideration of the different modes as analyzed in chapter 11.3.8., some forms of transport will allow for a reduction of travel time cost due to the productivity they allow. This has been assumed with factors ranging from 0% (private motorcycle) to 70% (air conditioned rail-based transport).

In an econometric analysis following the basic logic proposed here, these values logically work against the cost of travel time, arithmetically representing a negative cost value. In a holistic analysis of modal choice for investments in transportation systems, lifecycle analytics of such investments and considerations on the usability of travel time are becoming an increasingly important factor to consider.

11.5. Cost of Unrealized Economic Potential

As highlighted in chapters 4 and 6 on the deficit side, current main drivers on the infrastructural level include the lack of availability of sidewalks, the increased congestion driven by new real-estate developments, and various forms of social costs. While a calculation of cost is not possible due to the high degree of special factors and interdependency, insights into an understanding of dynamics and policy and regulation potentials is crucial.

11.5.1. Sidewalks Turned Into Parking Surfaces

A study commissioned last year by Phnom Penh City Hall estimated the economic cost of traffic jams to be costing the city approximately USD 6 million a month (The Phnom Penh Post, 2015).

One of the main reasons for congestion were illegally parked vehicles. While the underlying calculations cannot generally be quantified

since differing by use case and situation, a wider consideration needs to take into account several factors, including

- costs of lacking social spaces for citizens (recreational use)
- non-availability of urban surfaces for (suitable) business use such as hospitality/dining, including a loss of employment options and tax revenue
- costs of lacking greenery (for the urban significance of green spaces see brief discussion in chapter 4.2.)

11.5.2. Rapid New Commercial and Residential Developments

As of October 2019 in Phnom Penh, the government has approved 62 construction projects with a total surface area of 25,049,000 sq.m. Currently, an intense and rapid extension of both commercial and residential real estate is noticeable, much of it financed by Foreign Direct Investment. Most of these developments are positioned at the higher end of the market and come with considerable parking garages sized on the basis of assigning a number of vehicle spaces in incremental proportion to unit sizes. Parking facilities are integrated into buildings either as pedestal use, occupying the first above-ground floors, or as fully private or mixed public-plus-private parking. For illustrations of such developments, see chapter 4.1.

Non-expansion of Road Space at similar Proportions

A major problem arises from the fact that with the sum of these developments appearing even in the city centre, an attractor for car use is created in the form of readily available parking at destination, while there is no proportional extension of public road space that needs to carry vehicles going from

and to these developments. The fact that a significant number of such developments emerge comparably close to each other within central areas amplifies this problem (examples: Vattanac Capital Mall and Tower, Cambodiana Tower, AEON Mall, The Peak, NagaWorld, Golden Tower 42...).

Following Shoup's finding that free parking is "a fertilizer drug for car use" (Shoup, 2005), the trips generated from these massive buildings result in extra loads to be burdened by an already congested road system especially in the central areas of Phnom Penh. As the development of many Asian cities in the last four decades illustrates, isolated targeted interventions such as flyovers or even entirely new express road systems are unable to alleviate the growth in demand, mainly because terminal area road surfaces cannot expand.

Besides the induced demand in the Phnom Penh city centre, new condos and gated communities (residential) as well as office parks (commercial) in suburban areas replicate the problem and create additional traffic demands both on the links between city centres and suburbia as well as within suburbia. The latter is, together with new factory implementations, addressed by the Ring Roads (see chapter 5.2.).

A pro-rata calculation based on surface contributes to understanding the expected growth in vehicle presence and usage resulting from commercial and residential surface increase both within Phnom Penh and on the outskirts of Phnom Penh. On top of this come developments such as shopping malls, particularly intensive in terms of parking spaces: For example, the Aeon 1 Mall has four floors totaling 108,000 sq.m. One hundred and seventy covered parking spaces are available on the first floor out of a total of 1,400 vehicle parking spaces and 1,600 motorcycle parking

spaces. This translates into one car parking space per 78 sq.m of mall, and one motorcycle parking space per 67 sq.m of commercial space.

Economic Sustainability Potential of Mass Transit

To make new developments work and valorize them economically in a long-term and sustainable way, experiences from Los Angeles to Bangkok show that a loss of attractivity, translating into commercial success, of buildings that lose value due to congested vehicular access can best be addressed by mass transit: as an example Los Angeles, which until and into the 1970s privileged a purely car-centered development for the 1980s on progressively revised its policies, and started to massively invest in rail and bus rapid transit (today, L.A. Metro's "Office of Extraordinary Innovation" globally pioneers the integration of fixed-route and on-demand services in an urban context rather difficult to serve). Or Bangkok, with its population of over 8 million people is a very relevant example where restricted mobility and accessibility highlight the importance of transportation solutions as a factor to growth. Major investments in the city's mass transit system started in 1990. Among some of the important projects, the Thai government developed a 30-year Build-Operate-Transfer (BOT) scheme for the elevated rail transit system. The SkyTrain system, operational in 1999, runs through the center of Bangkok's commercial, business and tourist neighborhoods. The SkyTrain's initial segments had been built as retrofit into existing urban patterns, while and for further expansion is projected in accordance with urban development plans.

If no action is taken, negative externalities from loss of time through massive congestion surrounding new real estate will inhibit the invested capital from being as productive as it could potentially be based on other

parameters such as location, leading to it remaining significantly below its potential value: Massive new parking spaces create an illusion of accessibility, but due to the roadways leading there not expanding at the same pace, the developments will be difficult to access due to congestions and gridlock, making them perform below potential in terms of investment.

Land Value Capture

With transparent monitoring mechanisms as a prerequisite, Land Value Capture can serve as relevant methods of financing public urban mobility infrastructure projects, in the form of taxes, fees, etc. As the financial value of public land increases with new roads and transportation network construction, authorities can directly (and indirectly) recover part of that increasing value of public property. Land value capture mechanisms can help fund and pay back investments into transit, allowing public and private investors to valorize their investments on a long-term base by:

- introducing a mass transit system and connecting it to these developments.
- by law, funnel new investments so as to align new real estate along existing and future mass transit corridors.

11.5.3. Social Costs

Social cost impacts are similarly difficult to measure. A primary factor is the cost of non-accessibility, foremost a cost of social exclusion conditioned by underprivileged households finding themselves excluded from efficient and comfortable access to jobs, services, and infrastructure.

International experience shows that an overproportional affection expressed by an economic underperformance or non-participation of low-income, disabled or otherwise challenged households or individuals

can similarly best be prevented by performing mass transit systems. These thus generate positive externalities through an increase of economic potential and an decrease of negative cycles.

Kenyon et al. defined mobility related social exclusion as “the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services, and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility.”

Measures to quantify transport disadvantage (e.g., lack of mobility/accessibility) or transport-related social exclusion can include the availability of mobility tools (e.g., personal mobility and/or public transport accessibility); accessibility to opportunities (urban accessibility/potential accessibility); studies have adopted both vehicle ownership and accessibility to public transport services as the main indicators by which it is possible to identify transport disadvantages. These measures require socioeconomic disaggregation in order to understand vehicle or public transport accessibility levels and identify the extent of transport disadvantage.

11.6. Vehicle Productivity Losses

Vehicle Productivity losses affect commercial vehicles in their functions as productivity tools and investments:

- Vans and Trucks (light and heavy): Assuming a productive usage time of 18 out of 24 hours per day for a 12-wheeler truck, with a second-hand price that can reach USD 100,000 on import after taxes, and a remaining productivity lifetime of 10 years, we get a vehicle productivity loss of USD 15 per hour, plus the loss of revenue from freight haulage turnover.

- Buses, public service (long-distance and urban service): Productivity losses are mostly time losses triggered by congestion. A lower vehicle performance, mostly caused by a lower commercial speed, implies

for passengers, longer travel times (resulting in passenger-bound costs as per 11.3.1 and 11.3.)

for operators, a need for more vehicles to serve the same route and carry the same number of passengers (loss of hourly capacity to serve a route).

- Buses, private hire: basically, a calculation of productivity losses follows the same logic as for trucks.

Since private cars are being purchased and operated with the main function of being at the disposal and available to private individuals for their exclusive transportation and personal service needs (such as shopping, leisure travel...) their depreciation and writing off follows a different logic since they are not or not mainly productivity goods (unlike a private-car type sedan run by a car sharing service).

11.7. Negative Impact on Sustainable Transport Modes (Hinderings)

Roadway Use Efficiency

Slot usage for different vehicle types on a roadway is assumed to calculate the maximum hourly directional capacity of a 2-lane road: “Slot” means the vehicle itself plus reglementary security distances before, after and to the sides the vehicle:

The following overview discusses the productivity of slots per Unit of Time, for different modes, represented by vehicle types:

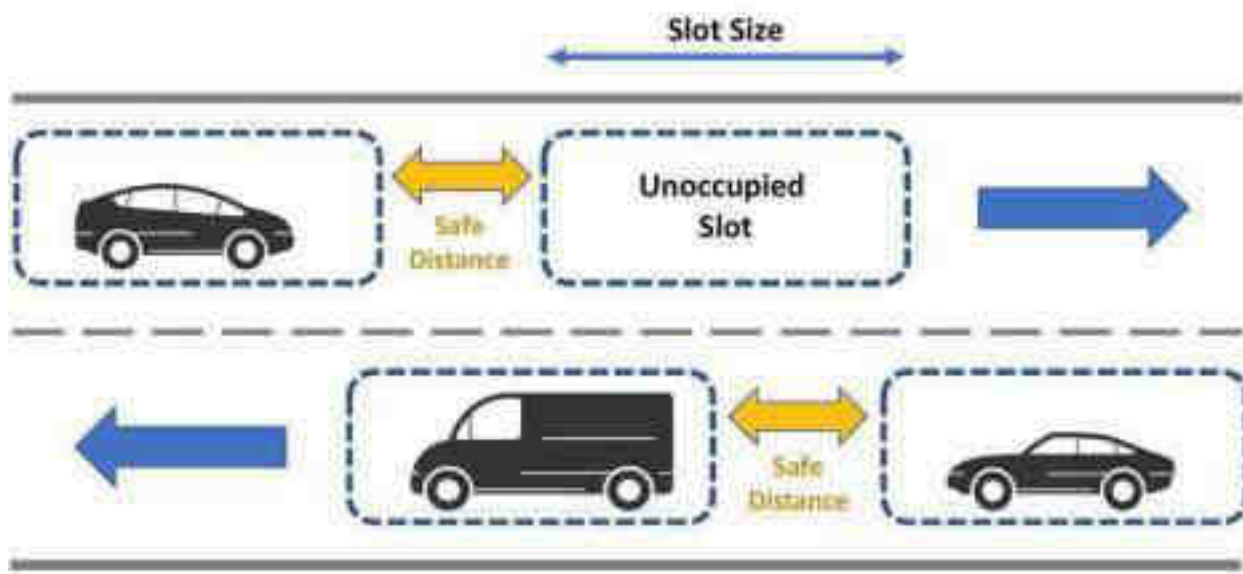


Figure 11.4. Road Capacity Usage Estimation (adapted from Walsh, 2019, with vecteezy elements).

Table 11.1. Efficiency of Roadway Use per Mode (Research Team, 2020)

Travel Mode	Comment
Motorcycle	Low-density mode with low adherence to traffic rules, requiring all other vehicle operators to take extra care. For safe operation, would legally require much more space than they actually take in Phnom Penh operation. Clusters congest lanes and intersections at peak times.
Car	Low-density mode with built-in safety space. Abundance of vehicles limiting thoroughfare throughput
Hired/RHA Taxi	Identical to car, roadside stops can block entire lanes for 30 secs
Motodop	Identical to motorcycle
Bajaj	Lower speed than cars, blocks lanes, and leads to constant overtaking that is the cause of accidents and limits thoroughfare throughput
Remork	lower speed than cars blocks lanes and leads to constant overtaking that is the cause of accidents and limits thoroughfare throughput
Bus (city bus)	high-density mode, blocks lanes while stopping if stops not correctly built

A comparison between JICA’s 2012 counts and the team’s 2019 counts (see chapter 6.2.6.) reveals the different evolution of vehicle categories, with a focus on the distortions created by the influx of Bajajs. The different speed categories of these vehicles have to be understood with regard to induced mutual

hindering, respectively their necessities for overtaking: This reduces the maximum mixed hourly capacity of a thoroughfare. From this perspective, the steep rise in Bajajs measured by the research team in fall 2019 is of particular concern.

11.8. Other Costs (Road Accident Costs, Noise and Pollution Costs...)

These values have been the subject of dedicated analytics by separate research teams, thus in this context are taken from external sources:

- Road Accident Costs (Richard Marshall & Runsinarith Phim, UNDP Cambodia)
- Noise Costs, Pollution Costs : Although

the noise pollution standards have been provided by Sub-decree #42 (CDC, 2010), to the best of the research team's knowledge, there is no comprehensive study and little literature on noise pollution problems and its related costs in Phnom Penh.

11.9. Cost Estimations: Composite Evaluation

11.9.1. Per-User Approach

Graphical Overview

PER USER APPROACH

- **Cost over Sample Distance** = Cost Increase **for unit of 1km travelled by one user**
 - based on average salary
 - based on middle class salary

Components for calculation of Time Loss Cost:

- **Roadway Use Efficiency = slots used per unit of time** associated to travelling (leisure, family)
 - considered for different vehicle types
 - considered for different occupancies (pax numbers)
- **Difference to Theoretical Most Efficient Solution**
 - Transit Options:
 - Bus / BRT with prioritization
 - Rail with own Right-of-Way
 - Walking
 - biking

N.B.: **Comparison becomes possible**
Since based on "per pax per mile" approach




Figure 11.5. Cost per user approach (Research Team, 2020)

To take into account the different components from a per-person, per trip approach, we adopt the following differentiation:

- Total Population of Phnom Penh (2020) =2,197,000 (calculated from 2,129,000 population in 2019—source: National Demographic Census Survey, 2019—adopting an average growth rate of 3.2% over 2008-2019)

- Simplified differentiation of Population into the following segments:
 - Middle-Class Income
 - Low Income
 - Non-Working (children and elderly, i.e. outside 15-64 age group, and non-working)

Table 11.2. Monetary values have been chosen by the research team as to be around an estimated center of fluctuation ranges, and credible as representative values for a sample calculation. The values below were chosen by the research team based on a set of sources, and are a deliberate simplification for the working purpose of highlighting dependencies and getting an idea of sizes. A more extensive analysis going beyond the limits of this report would need to consider that all income values as well as the population size follow a distribution, making manipulation much more complex thus not suitable for the present context (Source: JICA-PPUTMP, 2014, Research Team, 2020)

Population Group	Income Level (USD/month)	Absolute Number of Citizens in 2020	Percentage of total PNH Population
Low Income	USD 350.-	1,410,854	76%
Medium Income	USD 750.-	662,180	22%
High Income	USD 1000.-	124,095	2%

Broken down to a per-user, per time unit logic, the research team calculated cost fragments partly illustrated in tables 11.3. to 11.5. below. The goal is a representation of the net value of combined time losses both for passengers including delays in equipment use, deliveries, need for extra vehicles etc.

Based on a (theoretical) comparison with ideally efficient transit, where a much larger control of users of their time is assumed, the difference in cost is obtained in terms of

$$\text{time difference} \quad \times \quad \text{salary loss}$$

Based on the Phnom Penh demographics with a 70% active population and 24 working days per month, this translates into excess costs of roughly

> **USD 100.- per month (average)**

> **USD 200.- per month (middle class)**

thus in the range of USD 200 to 250 million per month, if the time lost in traffic was spent in a productive way (assumed hourly cost of time USD 2.- resp. USD 4.-).

11.9.2. Costs of Delays per User and Mode

Based on the above, taking all elements together, we get the following picture:

Table 11.3. shows the proportion of population cohort by trip purposes, by travel mode, and by income level.

Table 11.3. Proportion of population by (non)work-based trips, each travel mode, and income level (Source: Research Team, 2020)

Income Level	Low Income (USD 350.-)		Medium Income (USD 750.-)		High Income (USD 1,000.-)		Total
	Work	Non-work	Work	Non-work	Work	Non-work	
Private vehicle							
Motorcycle	38.8%	9.1%	40.6%	8.8%	2.0%	0.7%	100.0%
Car	21.9%	2.8%	54.3%	3.0%	16.3%	1.7%	100.0%
Public Transport							
Hired/Ride-Hailing Taxi	27.9%	29.8%	29.9%	5.0%	4.1%	3.3%	100.0%
Motodop	27.5%	33.2%	19.6%	17.0%	1.0%	1.8%	100.0%
Bajaj	19.5%	73.4%	2.0%	4.5%	0.2%	0.4%	100.0%
Remork	19.4%	11.7%	57.7%	8.2%	2.0%	0.9%	100.0%
Bus (city bus)	42.7%	43.5%	5.3%	4.2%	0.8%	3.4%	100.0%

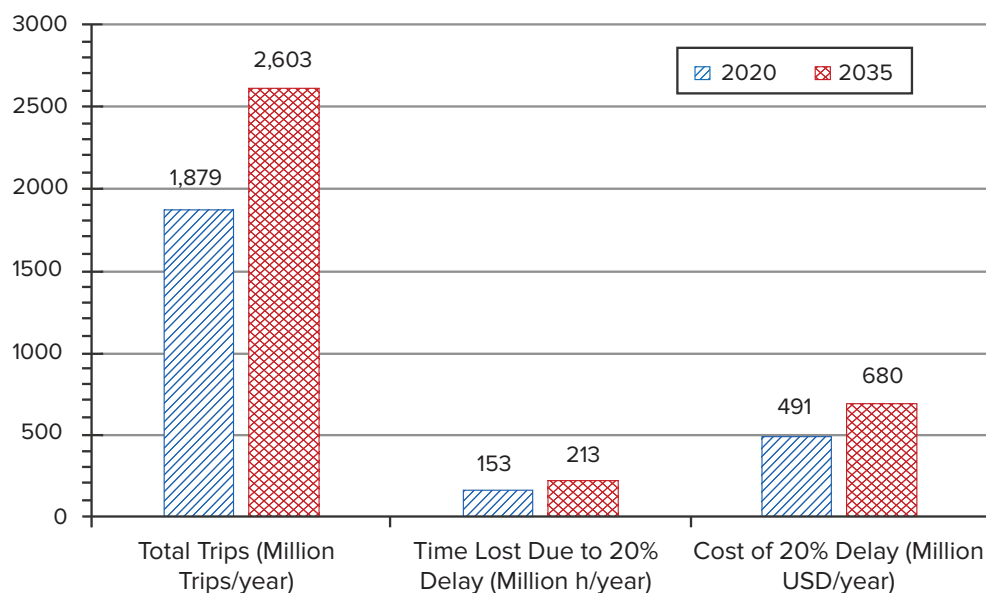


Figure 11.6. Estimation of the total trips, time lost due to 20%-assumed delay and cost of 20% delay per year in Phnom Penh (Research Team, 2020)

Figure 11.6. predicts the trip demand, time lost, and cost of delay of motorized vehicles per year in Phnom Penh from 2020 to 2035. If there is no efficient policy intervention and targeted countermeasures led by public authorities, the total trip demand will reach from 1,879 million to more than 2,603 million trips per year (about 38.5%) from 2020 to 2035. Due to an increase in the number of trips, the traffic congestion will become worse leading to urban traffic issues,

translating into approximately 153 million hours delay in 2020, with an assumption of 20% delay. This would increase to 213 millions hours of delay per year in 2035.

As a result, the research team estimates the total cost to Phnom Penh's Economy will be between USD 500 million and USD 700 million per year.

Table 11.4. Cost to the Phnom Penh Economy per hour of delay in transportation, per income class and mode in USD (Research Team, 2020)

Income Level	Low Income (USD 350.-)	Medium Income (USD750.-)	High Income (USD 1,000.-)	Negative Cost Applied
Overhead Cost	10%	15%	20%	
Private vehicle				
Motorcycle	1.93	4.32	6.00	0.0%
Car	1.73	3.88	5.40	10.0%
Public Transport				
Hired/RHA Taxi	1.54	3.45	4.80	20.0%
Motodop	1.83	4.10	5.70	5.0%
Bajaj	1.54	3.45	4.80	20.0%
Remork	1.54	3.45	4.80	20.0%
Bus (city bus)	0.77	1.73	2.40	60.0%

This table 11.4. shows the cost per hour per delayed passenger to the Phnom Penh economy. Average values have been chosen for income structure, labour overhead costs

and negative costs of modes (see section 11.4.2.), the latter being a proxy for the capacity to make an efficient use of time while travelling in specific mode.

Table 11.5. Trip frequency and potential

Transport Modes	Passenger Mix (Income Classes)	Vehicle Pax Occupancy	Cost of vehicle delay per hour [USD]
Motorcycle	100% Low-Income	1.4	2.7
Car	100% Medium Income	1	4.3
Car	100% High Income	1.9	10.3
Hire/Ride-hailing Taxi	100% High Income	1	4.8
Motodop	100% Medium Income.	1.4	5.7
Bajaj	100% Medium Income.	1.8	6.2
Remork	100% Medium Income.	2.1	7.2
Bus (city bus)	50% L, 50% M	80	100
Bus (city bus)	40% L, 40% M, 20% H	80	118

(Data source: JICA-PPUTMP, 2014, Research Team, 2020)

Table 11.5. shows the direct cost to the Phnom Penh Economy of a vehicle with an assumed typical passenger mix getting delayed by one hour (cost can be calculated linearly from

there). Occupancy numbers have been taken as averages where available in literature, or chosen as scenario development by the team.

Key Takeaways:

- The current system incurs high external cost related to the inefficiency, respectively non-suitability of the modes currently carrying the major load of urban transport. It becomes obvious that on-demand paratransit vehicles such as Bajajs are not suited to a role of main providers of public transport.
- The lack of right-of-way and timetable stability of the current Citybus system results in high externalized costs that ultimately have to be borne by the Phnom Penh economy and the civil society even in a scenario in which buses are mainly used by low-wage workers.
- Attractive public transport that also attracts a larger share of medium- and higher income patrons is a major measure to reduce the external costs of urban mobility while contributing to an overall reduction of negative externalities.

12. CONCLUSIONS

Summary:

This chapter discusses the overall findings and conclusion from earlier chapters. It suggests the benchmarks for policy discussion on how to transform the urban mobility in Phnom Penh towards an inclusive and equitable urban accessibility.

12.1. Estimations of Cost Savings

Chapters 5-9 and chapter 11 present the various contextual factors to observe and user-centered calculation measures to be taken into account.

As a summary and conclusion, on a strategic level of infrastructural investments, modal choices, and development, the research team suggests that the following factors be taken into account:

12.1.1. Connectivity

Connectivity is a terminology widely adopted in the current debate on integrated multimodal transportation systems, widely seen as the only viable option to curb private car dependency and ownership in a long-term perspective.

But connectivity goes far beyond multimodality. In the sense adopted here, it is an urban design concept that integrates the built environment, the planning of infrastructure, and the programming of spaces with integrated transportation offers.

Ultimately, the notion of connectivity always implies aspects of equity of access, fostering patterns of social justice. Besides, comfortable and reliable connectivity levels in a transport

system are a major asset allowing it to compete with the perceived comfort of a private car.

12.1.2. Traffic Fluidification

•**Road Pricing:** The Municipality of Phnom Penh has taken numerous initiatives to turn Phnom Penh into a “smart city” (The Phnom Penh Post, 2019c). Indeed, with its fast data networks and established mobile data presence in everyday life, a concept of dynamic, electronic congestion charging—equally targeting all road users, independently of class and status, a premium at peak times, while allocating discounts at low-usage times—ultimately works towards a more equitable city access, thus benefiting all road users. A more fluid road-based travel can gain acceptance with citizens, so long as the only basis for a pricing decision at a specific time is the demand at that very time.

One of the possible role models can be Singapore, where a highly elaborate, dynamic steering of road pricing has contributed to establishing better and more equitable chances for all road users.

• **Small Urban Cargo / Urban Freight Distribution:** The Municipality of Phnom Penh currently does not allow trucks to enter the inner city during daytime (unless an exceptional permit is granted). Still, as discussed in chapter 7.1 & 7.4., urban cargo

distribution shares the same infrastructure as passenger-carrying services, thus has to be coordinated and aligned with them in some form.

Phnom Penh has the particularity of having an important number of freight-intensive trading and manufacturing activities within the city limits. Increasing difficulties in urban cargo deliveries due to congestion or other factors result in doing economic damage to these businesses. Currently, some “workarounds” such as Remorks illegally converted to and operated as freight carriers exemplify the rising demand for dynamic and flexible small cargo distribution. Given Phnom Penh’s excellent cellular data network coverage, innovative solutions using standardized reusable mini-containers and an efficient on-demand small cargo routing system should be considered and encouraged in its development. The core aspect needs to be a bundling of cargo into specific vehicles to reduce the overall number of freight vehicle movements within the city and to some suburban or urban, rail- or water-connected distribution hubs and similarly accelerate the individual trips by benefiting from a less congested road space, increasing their on-time performance.

Also, it is important that any reprogramming and re-attribution of urban road space in Phnom Penh include loading bays for cargo vehicles in immediate proximity of businesses, since anything else will lead to cargo vehicles continuing to be unlawfully stopped on sidewalks, bus corridors, bike paths or roadways, hindering other road users.

12.1.3. Enhancement of Walkability

- **Sidewalks:** Problems generated by the current, ongoing occupation of sidewalks for non-pedestrian use such as car repair businesses, trade / merchandise storage or vehicle parking have been mentioned in chapters 5.5. and 5.6.

The implications of this go beyond the sidewalks and pedestrian use themselves, since the lack of walkability makes the use of public transport (such as the City Bus) unattractive and economically uncompetitive for middle-class users since accessing stops is many cases difficult, tedious and unsafe. Any strategy of public transport deployment thus needs to be aligned with efficient revival and re-assignment measures for sidewalks.

12.1.4. Private Fleet Control

- **Private Motorcycles:** Currently the backbone of transportation in Phnom Penh, factors such as their pricing, lack of driving license needs and safety regulation enforcement lead them to become greatly popular. However, the parking situation, especially in popular sites, is unsustainable in terms of consumption of urban space and structurally comparable to the problems of private car parking.

Future uses of motorcycles should focus on a targeted use of their modal advantages such as suitability to the countryside or otherwise partly fixed roads: With the ongoing rapid extension of Phnom Penh at its urban borders, motorcycles can provide future last-mile services from rural or suburban homes to the next mass transit (ail / Metro / BRT or AGT) station. This will require extensive motorcycle parking facilities close to these stations, but keep many out of the city center by providing economic incentives such as free parking at rail stations combined with a road pricing charge for accessing the center. In dense downtown areas, many motorcycles will be able to be replaced by e-Bikes, in extension of the suggestions of JICA-PPUTMP (2014).

- **Private Cars:** As a low-density mode, privately-held cars are mainly a prestige symbol and chosen for comfort / provincial access reasons.

- **Private Hire Cars:** Their current role is mainly that of a taxi replacement respecting ride-hailing service. While presenting a higher degree of informality than app-enabled ride-hailing such as Grab, Lyft or Uber services, the functionality to the customer remains comparable. It is to be expected that private-hire cars will soon be shifted onto platforms such as PassApp or Grab that are currently predominantly serving Bajaj-based service.

12.1.5. Sustainability of App-Driven Ride Hailing and Paratransit Operations

- **Ride-Hailing, app-enabled:** As per research undertaken by Schaller (2018) and UC Davis (2017), ride-hailing can be a major source of congestion if deployed and used as a major mode of transportation within dense inner-city areas. In a holistic consideration of its role within the transport system, app-enabled ride-hailing performs best and can play out its functional advantages if used as a first/last-mile complement to mass transit.

Currently in Phnom Penh, Bajajs, with their commercial speed higher than that of Remorks, are widely being used in a functionality and role overlapping with the role that public mass transit and/or taxis could have. For transit, the current role of Bajajs can be seen as a direct consequence of the deficits of the City Bus system (see 6.1.1.)

- **Ride-Hailing, street hired:** Unlike app-enabled ride hailing, it is less easy to integrate in an automated way as part of intermodal travel chains. Like app-enabled ride hailing, it basically should fulfil a paratransit role, not one of transit replacement: As deduced in chapter 11.8., long Bajaj trips all along their way underuse

road capacity by blocking lanes to traffic of larger and/or faster vehicles that would be more productive within the same time-slots on a roadway.

- **Bajajs:** This vehicle type had debuted as Piaggio’s cargo tricycle “Ape”—the busy bee beside its elegant, agile moto-scooter sister the wasp (“Vespa”)—in postwar Italy. Eventually, licensees in southeast Asia developed a passenger carrier out of the cargo vehicle, starting its global career as “Tuk Tuk”, referring to its two-stroke engine. Apart from minor modernizations such as conversions to CNG (Compact Natural Gas) operations or a more modern dashboard, the basic construction today remains the largely unaltered 1940s design. In urban road traffic of the 2020s, operating such vehicles with zero safety features side by side with modern cars and trucks is not only an ecological anachronism, but downright dangerous for occupants.

The only comprehensible reason for the existence of Bajajs, named after their Indian manufacturer, is their low purchase price. Legalizing their importation into and operation in Cambodia in 2016 sparked off a boom of this vehicle type: Attaining speeds higher than the traditional Cambodian motorcycle semi-trailers “Remork”, Bajajs’ popularity with passengers lies in their ability to provide point-to-point (door-to-door) operations with a high granularity, even accessing small alleyways. Still, considering their gross discomfort—exposure to pollution and elements, heat, humidity and noise—their widespread use in Phnom Penh can only be explained by the absence of metered taxis, the integration of Bajajs into ride hailing platforms, and the nonexistence or poor quality of mass transit services.

As analyzed in chapter 11.7., the speed of the Bajajs is faster than that of bicycles and remorks,

but slower than cars, trucks and buses. This puts them in the dangerous sandwich position of permanent traffic obstacles and continuous generators of inefficiencies in roadway use. A new generation of micro-vehicles for functionally comparable services would only be reasonable to operate if they can circulate in mixed traffic at identical speeds and safety levels, and operate as complements to mass transit instead of providing crosstown services.

New or other forms of paratransit such as on-demand shuttle services or classic taxis can serve as replacements. Given the important rural-city migration that the emergence of the occupation as Bajaj owner/driver has triggered with a predominantly uneducated population, a coordinated phasing-out of Bajajs would have to be accompanied by a re-education program giving former drivers access to new, better jobs.

12.1.6. Remarks on Mass Transit Modes

- **Commuter Rail:** The current rail lines that have been put back in operation are, as explained in chapter 6.1.2., mainly used for freight, long-distance passenger services or special short-route services such as the Airport Train. The existing trackage would allow for a more extensive use, including a scheduled (e.g. hourly) commuter rail service that could be initiated by refurbishing some decommissioned en-route stations or setting up new ones by installing simple trackside platforms in locations attractive for a new rail service. Also, the research team found that some decommissioned rail corridors have seen their tracks removed, but would still be available as mainly uninterrupted transportation axes that are currently serving areas with high dynamics of real estate developments, while being underused for transportation. In the logic

of the European “tram-train” concept, the existing rail lines could be complemented by putting trackage back in such corridors to serve the local population and create vectors for sustainable real-estate development. The inner-city connection could easily be achieved by extending track within some urban road space beyond Phnom Penh railway station: It could be a quick fix helping bring efficient but low-cost rail transit while the decision and implementation of future grade-separated rail systems such as a metro or an AGT would be undertaken. A classic rail system built on existing backbones would use the same technique and implementation as the airport link that was achieved within a record 8 weeks’ time only. Vehicles could be imported using donated, second-hand light rail vehicles that do require only light infrastructure.

This would have several positive effects with comparably limited investment, including the option to channel residential developments as well as services attracting a large number of passengers on a regular basis, such as educational facilities. An example is the ITC (Institut de Technologie du Cambodge, Cambodia Institute of Technology) and RUPP (Royal University of Phnom Penh) campuses where the railway line passes close by, but trains currently do not stop. Feasibility has been discussed with the Royal Railway Group’s CEO, who views such ideas favorably.

- **Metro / AGT / Skytrain:** Projected as an entirely new system, several technologies and variations are currently being proposed and under review. Common to all is their basic characteristic of being grade separated (elevated, underground or mixed), thus not interfering with road-based urban traffic. To reach its full potential, such a system needs careful



Figure 12.1. Schematic illustration of existing or re-activated rail corridors that could rapidly be set up to serve areas of intensive residential and commercial development (Map Data ©,Google, Inc. 2019, Research Team, 2020)

planning and full long-term integration with urban land-use schemes and real-estate investment planning, following a local adaption of the proven concepts of Transit-Oriented Development (TOD) and New Urbanism (Vuchic, 2005 and CNU, 2018). It is important to realize that the implementation will take 5 years minimum to begin operations and approximately 10 years to realize positive urban externalities of a network.

On a medium- and long-term scale, such a system as backbone is a prerequisite for any sustainable, integrative, equitable, affordable, reliable and sustainable urban transport in Phnom Penh. All other modes, both fixed-route and on-demand, will have to be aligned and integrated with it.

- **Urban Cable Cars:** As mentioned in chapter 5.4, the paucity of bridges and the insufficient capacity and inadequate deployment of ferry services are a major obstacle to an Eastern expansion of Phnom Penh across the Mekong River. As complement to and fully integrated with all other modes discussed in this report, a cable car serving the axis ITC—Railway Station—Waterfront and crossing the Mekong could provide a quick relief to the current unsatisfying and implicitly development-hindering situation, which results in expensive deficits in transportation offers. It has been included as one of the suggested quick-to-implement routes and services in figure 12.1.

It is to be noted that an urban cable car can be planned and set up in less than 12 months, is comparably cheap to build, runs entirely emissions-free, and can carry as many people per hour and direction as a bus route served with articulated 18.75m-vehicles at 2-minute intervals.

- **Bus Rapid Transit (BRT):** The deficits and challenges of the current Phnom Penh city bus system are discussed in chapter 6.1.1. While the current debate on a bus corridor on Monivong Blvd, Charles de Gaulle Blvd, and Monireth Blvd is taking up speed within the political discourse, it is obvious that the impact of a classic bus system, even if enhanced by stretches of right-of-way on dedicated corridors, will remain limited, and so will be its potential to reduce the negative externalities of the current transport layout. Since the time until completion of major Metro/AGT axis needs to be addressed if the potential of the current and foreseeable economic development dynamics in Phnom Penh are not to be hindered, an intermediate-capacity solution that is quick to implement, of good performance and can be partly adapted to complement the AGT once it is completed will be necessary.

The chapter on commuter rail discusses the potential to quickly re-introduce a temporary or permanent rail service making use of existing or easily adaptable infrastructure. Still, as explained in the dedicated section, this commuter rail concept is limited to some specific corridors. In all other places, a BRT built within existing roadways is an adequate complement: Politically, it has the advantage of maximizing the capacity of the bus corridors currently being discussed. A model can be the very successful TransJakarta system, with two major amendments: A BRT in Phnom Penh would have to be electrified from the beginning

to maximize vehicle size, thus capacity, which is one of the few drawbacks of TransJakarta in its current form. One of the authors of this report is involved in the planning of its electrification: Modern In-Motion-Charging Trolleybus technology allows for double-articulated vehicles that can also run on extensive off-wire sections without the drawbacks of diesel or battery-only buses. Secondly, a strict prioritization of buses at intersections is necessary to maximize commercial speed and minimize vehicle productivity as explained in chapter 11.6.

12.2. Levels of Intervention

12.2.1. General Approach as per results

As mentioned in detail in chapter 12.1., the master concept behind all evolution, planning, investment and development decisions in Phnom Penh's urban transport sector should be the minimization of negative externalities and the maximization of positive ones. Cost is, if not a direct factor, a suitable proxy variable for a broad, societal assessment.

12.2.2. Support for Modal Choice Decision Making

Based on the analytical projections of chapter 12, the research team finds insights that permit for some deductions for ongoing Land Transport Planning:

- **Paratransit** can, outside temporary situations such as construction phases or service disruptions, never be an economically viable replacement for fixed-route transit due to, as mentioned, its comparable inefficiency when used for carrying large numbers of passengers within identical origin-destination pairs.

Thus, a re-Assignment of Paratransit to the areas where it can play out its strengths—flexibility, accessibility, often good knowledge of a local terrain—appears as urgent

- **Fixed-Route** transit should be implemented with priority over all other modes. In a well-balanced system, these will be complementary to it.
- **Infrastructure** and its situation-adequate, efficient deployment and maintenance has to be recognized for its social value partly represented through economic cost reductions.

12.2.3. Sketching the Road Ahead: Suggested Three-Stage Proceeding

Given the scope of the financial investments and the impact on citizens' lives, Infrastructural planning as a base for urban development requires a coordinated overlay of short-term and long-term measures. The hierarchy of a three-step process has been defined by the authors to mirror the different scopes of investment:

Phase S: Short Term, approximately 2020-2025. This comprises transitory investments for quick fixes and the short end of master plans.

Phase M: Medium Term, approximately 2025-2035. This phase represents the extended scope of master plans that significantly alter transport infrastructure and delivery. They include major investments in heavy infrastructure.

Phase L: Long Term, approximately 2035-2050. This phase represents concept plans that mirror fundamental paradigm changes in urban planning, rewriting major layouts of the city through centennial infrastructural measures.

The research team suggests moving ahead in a 3-step process with its key elements as follows:

Phase S: Short-Term 2020-2025

- Clear political priority given to mass transit planning and implementation; private automobiles restricted to connections with the provinces and preparation of use restrictions within Phnom Penh
- Parking enforcement and ban on parking on sidewalks
- Citybus system with own right of way on major arteries, electronic prioritization at intersections and enforced timetable stability
- Integration of mass transit planning with revised land-use masterplans: retrofit mass transit to zones and relations of highest expectable demand
- Rapid Planning for a “quick-fix” intermediate-capacity mass transit system with multimodal components and integrated into digital sales channels

Phase M: Medium-Term 2025-2035

- Decision-making (systemic and geographical choice) and construction of grade-separated, possibly automated mass transit system
- Operation of a mixed trolleybus BRT / classic rail transit system and alignment of residential and commercial developments along these corridors. Ideally, some BRT routes prefigure future metro routes
- Planning of mass transit infrastructure (stations) as part of an intermodal public transport network including demand-responsive offers later to be supplemented by self-driving taxis and automated small cargo carriers
- Phasing out of Bajajs and replacement by contemporary paratransit services seamlessly connecting to fixed-route services

- Mandatory implementation of local walkability standards as part of any development project
- Introduction of limited-access zones for privately-held passenger cars in large areas of Phnom Penh's inner city, including a ban of motorcycles and replacement by subsidized e-bikes and e-cargo-bikes that are indigenously produced

Phase L: Long-Term 2035-2050

- Land development focused along metro, rail and BRT axes
- Automated paratransit service intelligently combining passenger and cargo last-mile services
- Ban on gasoline-powered vehicles in Greater Phnom Penh, dynamic congestion charge for remaining road vehicles

12.3. Impacts of COVID-19 on Urban Mobility

Urban mobility is likely to undergo significant changes due to ongoing COVID-19 and future potential outbreaks. The citizens' choice of travel modes is affected by the increasing risks associated with crowded places and social distancing norms. A significant development

in the modal split is the declining share of public transport and the substitution by road transport. Walking and bicycling also increase in several cities.

In Phnom Penh, the levels of urban mobility to major destinations (e.g., Educational institutions, retail & recreation, parks, transit stations, workplaces, and touristic places) have been found to decline since the outbreak. The overall urban mobility (trip distance & frequency) experienced the highest decrease (almost 80% drop) during the mid-April travel restrictions and has gradually recovered to less than 30% drop.

Therefore, it is necessary to address the issues associated with the current COVID-19 outbreak and well prepare for the coming "new normal" to ensure safe and healthy mobility. This includes preventing measures (e.g., wearing mask, monitoring body temperature), social-distancing norms (e.g., physical distance, telecommunication), teleworking & flexible departure time, online classroom, and resuming public transport services with safe & healthy operations to serve transport needs. Where possible, the layout of crowded urban streets should be re-configured to allocate sufficient street space for maintaining the safe physical distance.

13. FUTURE RESEARCH

Based on the insights of this report, the authors identified a need for further research in the following areas:

13.1. Environmental costs (air pollution, noise)

While the number of registered vehicles, composed mostly of second-hand imported vehicles, continues to increase, the information regarding the detailed costs relevant to the current air and noise pollution in Phnom Penh remains scarce. Scientific research on these environmental costs might help both transport planners and the authorities to understand more about our living environment: how much air and noise pollution in the city is due to the transport sector, industrial sector, agriculture sector, etc. These environmental costs may be currently (or will soon be) increasing at an alarming rate, which requires appropriate interventions by the government. Research on these environmental issues is needed, and it will be useful for planning for a more livable city.

13.2. Detailed study to estimate demand for urban rail and/or BRT.

It is important to have scientific research with a systematic design and framework for local context to predict the demand for urban rail

and/or BRT services in the medium-term and long-term period, and to do it with the goal of a multi-modal, integrated transit + paratransit network in mind. Such demand prediction will help transport planners and authorities to understand the transport needs of citizens and propose corresponding regulations and policies for urban mobility. As explained in chapter 12, an electrified BRT that for robustness reasons uses modern in-motion-charging trolleybus technology, is to be analyzed in its roles both as a pre-rail stage, as well as a later complement and feeder to urban rail.

13.3. Feasibility of Smart City Concepts

Phnom Penh already has a high rate of adoption of digital technologies, and thus should investigate how modern mass transit, complemented with state-of-the-art paratransit, can be a critical component of emerging Smart City concepts. This is of particular interest with regard to the development of peripheral and suburban spaces, where unlike existing areas an integrated planning can happen “from scratch”, and not as retrofit as in existing, densely built areas. Ultimately, this is about securing car-lite transportation in suburban areas of Phnom Penh, resulting in less traffic issues, less environmental impacts, better economic performance, and a more livable city overall.

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16. APPENDIX

16.1. Example for Licensed On-Street Parking

Despite several pay-parking projects being proposed, only a few projects have been implemented. For example, Sonatra Carling, the Japanese-Cambodian joint venture, was the first company that built (and operates) automated toll-parking systems in July 2016 with 31 mechanical parking stands. The system is located behind Wat Ounalom near the city's riverside (on-street parking). The system introduced a ticket-based parking

scheme whereby drivers are charged for the time their vehicle spends in the parking dock. It was reported that the parking stands received about 200 cars per day, with the majority spending less than one hour, with the charge of USD 0.25 per hour. On average, the stands were operated at a low 40% capacity. This on-street pay-parking project has been considered for expansion into other areas of the city. However, this system appeared to have been put on hold, for unclear reasons, as of November 2019. Figure 15.1 shows the situation of this pay parking system.



Figure 16.1. On-street pay parking system (left) and paying booth (right) that was not in use, Near Wat Ounalom, Nov 2019

16.2. History of Public Bus Service in Phnom Penh

The first one-month public bus service in Phnom Penh was pilot-tested by Phnom Penh Capital Hall and Japan International Cooperation Agency (JICA-PPTUMP, 2014). Twenty-three air-conditioned minibuses (29

seats) were operated along two major roads, with the total length of about 17 km (Phun et al., 2016). Two flat fares were implemented: KHR 500 (\cong USD 0.13, as exchange rate of June 2001) for the first 5 days and the last 8 days, and KHR 800 (\cong USD 0.21). The daily average numbers of bus users were 4,687 for 500 KHR and 2,738 for KHR 800. However, the bus was shut down after a one-month extension, mainly due to financial reasons.

In February 2014, the Capital Hall and JICA again tested the public bus service for one month. A fleet of 10 air-conditioned buses (35 seats) was operated along Monivong Blvd (total length of 7.5 km). With a flat fare of KHR 1,500 (\cong USD 0.37, as exchange rate of February 2014), the average number of daily bus users was 1,546. The bus fare in 2014 was higher than that in 2001 due to the increased gasoline price and the users' most acceptable fare level. In September 2014, the bus service was extended and the servicing route was expanded from one to three routes, with a total length of 51.5 km, using a total fleet of 43 buses. From October 2014, a fare discount policy has been implemented. The bus service is free for specific groups of bus users including students, children, and the disabled persons. With this fare policy, the average number of daily bus users for all three bus lines has substantially increased from about 2,500 to more than 6,000, but about 40.0% of them are free riders (Phun et al., 2015a). Other routes have been added over the next few years. The public bus services continue because the government seemed to show a stronger support for the

public bus as necessary for the development of Phnom Penh.

16.3. Locations of Traffic Count Surveys in 2012 and 2019

Figure 15.2 and Figure 15.3 show the locations of the traffic count surveys in Phnom Penh by JICA's study team in mid-2012 and by this study team in end-2019, respectively. Results from two locations of each traffic count survey could be used to investigate the change in modal share in Phnom Penh over 2012-2019. The first location is the traffic along Russian Blvd, which was denoted as "SL6" in Figure 15.2 and as "L1" in Figure 15.3. The second location is the traffic along National Road 6, which was denoted as "SL9" in Figure 15.2 and as "L2" in Figure 15.2. The traffic count survey for SL6 & SL9 was done for 24 hours, while that for L1 & L2 was done from 6h30 to 19h30 (13 hours). Regardless of the total traffic volume of different counting duration, this report uses the proportion of each travel mode for comparison.



Figure 16.2. Locations (SL1-SL9) of the traffic count survey in Phnom Penh by JICA's Study Team in mid-2012 (JICA-PPTUMP, 2014)

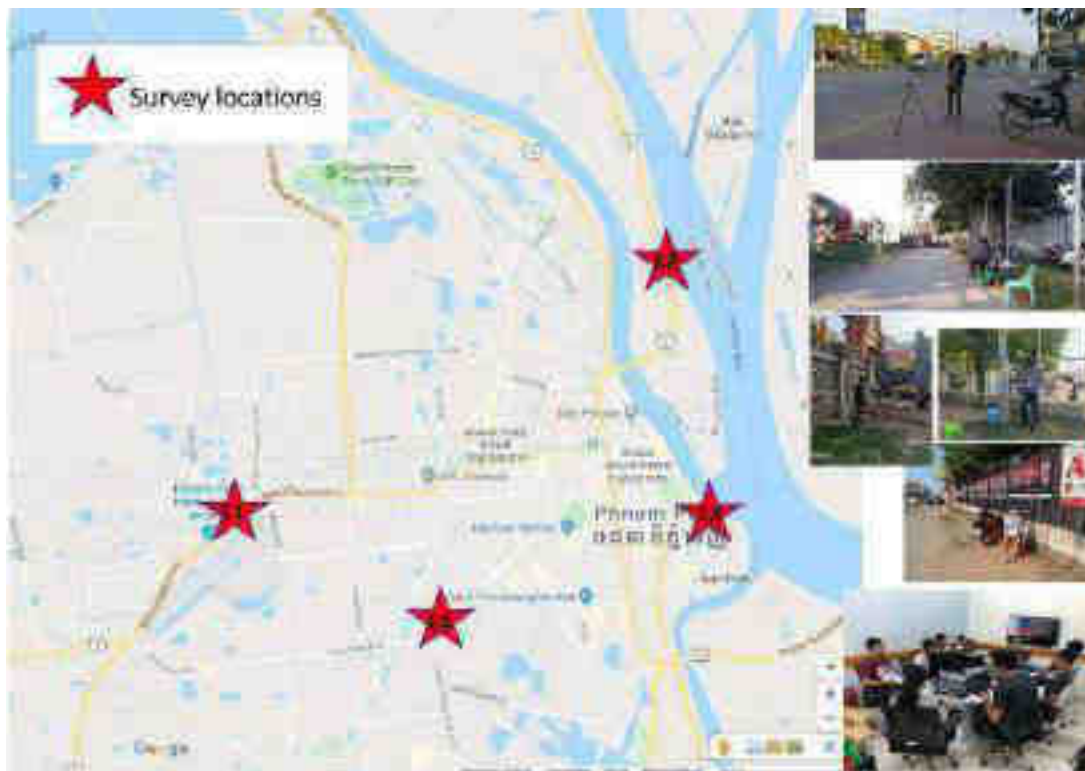


Figure 16.3. Locations of the traffic count survey in Phnom Penh in end-2019 (Research Team, 2019)

16.4. List of Interviewees with the Research Team

Table 16.1. List of interviewees (Research Team, 2019)

1	H.E	ChanTheory	Heng	Head of Phnom Penh Traffic Police, Ministry of interior
2	Dr	Chenda	Heu	Ministry of Land Management, Urban Planning, and Construction
3	Mr.	Chun Hieng	Sun	Deputy Director, Department of Capital, Khan and Prov. Affairs, Ministry of Interior
4	HE	Pharat	Nuon	Vice Governor of Phnom Penh
5	Mr.	Sokhim	Ean	Governor of Phnom Penh City Bus
6	Mr.	Sophearith	Thiv	Department of Air Pollution, Ministry of Environment
7	H.E	Sothirith	Sek	Ministry of Land Management, Urban Planning, and Construction
8	Dr	Borith	Long	Deputy leader of a urban transport project under ADB
9	Dr	Botumroath	Sao	ADB Consultant
10	Dr	Chevillard	Julien	Cambodian Climate Change Alliance
11	Mr.	Guiry	John	CEO, Cambodian Royal Railway
12	Ms.	Hough	Olivia	MD Impact Hub Phnom Penh
13	Ms.	Mossard	Melanie	Marketing Manager
14	Mr.	Kimchoeun	Pak	UNICEF Consultant
15	Dr	Makathy	Tep	Director of Cambodian Institute for Urban Studies
16	Mr.	Ratanak	Kong	Founder, Road Safety Institute
17	Dr	Sophal	Chan	Director Centre for Policy Studies
18	Dr	Sothea	Kok	National expert, Royal University of Phnom Penh
19	Mr.	Sovann	Kong	Deputy of a road safety project
20	Dr.	Vanna	Sok	Country Manager, UN Habitat
21	Mr.	Sophal	Khem	Director, Road Safety Unit, Cambodian Red Cross
22	Prof.	Yuvara	Aun	Lecturer, Royal University of Phnom Penh, Car Dealer

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