Chapter 8 Development Scenario

8.1 Development Scenario of PPUTMP

8.1.1 Five Development Strategies in PPUTMP

PPUTMP sets the following four target indicators for the development goals, "To maintain the people-/environment-friendly urban conditions and vitalise the urban activities".

- Target indicator 1: To develop the urban transport system with more than 30% of total trip makers using public transport in 2035.
- Target indicator 2: To develop the urban transport system with less than 1.0 of volume-to-capacity ratio in the city centre.
- Target indicator 3: To maintain the travel speed in the city centre at a level higher than 20 km/h.
- Target indicator 4: To develop the urban transport system with 10% reduction of volume of air pollutants from vehicles such as CO_2 and NOx from the "Do-Nothing" case.

The following five strategies for public transport, highway and traffic management were proposed in the PPUTMP for achieving these targets.

- Strategy 1 in PPUTMP: Formulation of people and environmentally friendly urban transport system with high mobility and catering to the needs of citizens.
- Strategy 2 in PPUTMP: Formulation of physical framework of the city and creation of smooth connection between major cities in the Mekong Sub-region.
- Strategy 3 in PPUTMP: Maximum use of existing transport spaces including underground and elevated spaces in the city centre.
- Strategy 4 in PPUTMP: Efficient traffic flow for commodity
- Strategy 5: in PPUTMP Environmental/social considerations and establishing appropriate urban transport-related organisations are the fundamental concept to develop the master plan.

8.1.2 Review of External and Internal Factors of Development of PPUTMP

PPUTMP set the external and internal factors of urban transport development in accordance with socio-economic indicators and the direction of urban development. The differences between the assumed external and internal conditions in the development scenario of PPUTMP and the current status are summarised as follows.

- [Socio-economic indictor]: The population of Phnom Penh reached 2.28 million in 2019, which is close to the estimated population in PPUTMP (2.4 million in 2020). On the other hand, the percentage of households with one or more car reached 27% in 2020, higher than the percentage assumed in PPUTMP (24% in 2020).
- [Direction of urban development]: As anticipated in PPUTMP, redevelopment in the city centre and large-scale urban development in the suburbs is ongoing. However, from 2008 to 2019, the

population of the CBD is decreasing at the CAGR of -1.04%, while the population of other areas is increasing at the CAGR of 5.52%, which implies the city centre is becoming hollower.

- [Direction of urban transport development] The public transport network was developed with City Bus, however, the modal share of public transport, city bus, accounts for all the trips made in Phnom Penh is not more than 1%, which is significantly lower than the target of PPUTMP, 10%. Traffic congestion remains in the city even though some highway projects such as construction of ring roads and flyover/underpass at major junctions are in progress.

Table 8.1.1 Assumed External and Internal Factors and Conditions in PPUTMP

Scenario	2016	2020	2025	2030	2035
Socio-economy	Population: 2.14 million GDP per capita: USD 1,345 (2016)	Population: 2.40 million GDP per capita: USD 1,892 (2020)	Population: 2.64 million GDP per capita: USD 2,899 (2025)	Population: 2.77 million GDP per capita: USD 4,503 (2030)	Population: 2.87 million GDP per capita: USD 7,053 (2035)
Urban Development	-Redevelopment of city centre (commercial business buildings, condominiums) -8 large-scale urban development in suburbs -Urbanisation in the western, northern, and southern area	Same as on the left	-Redevelopment of city centre (commercial business buildings, condominiums) -Development of public transport transit terminal and development in its vicinity -Urbanisation in the western, northern, and southern area -Relocation of factories and logistics facilities to suburbs	Same as on the left	Same as on the left
Basic Concept of Urban Development	-Rationalisation and optimisation of traffic flow in the city centre (improvement of signals, one-way streets, parking management, regulation related to logistics) -Enhancement of citizens' mobility by introduction of public transport -Support/guide for urban development in suburbs (highway, public transport)	-Development of ring road network -Improvement on comfortableness of sidewalks -Enhancement of citizens' mobility by introduction of public transport -Support/guide for urban development in suburbs (road, public transport) -Transport network for large-scale development	-Development of ring road network -Enhancement of citizens' mobility by introduction of public transport -Support/guide for urban development in suburbs (road, public transport) -Support/promotion for rearrangement and of logistics facilities and rationalisation of logistics facilities and factories	-Redevelopment of city centre along with transport hub and promotion/support for new urban areas in suburbs with TOD -Enhancement of citizens' mobility by introduction of public transport	Same as on the left
Modal share of Public Transport	5%	10%			30%

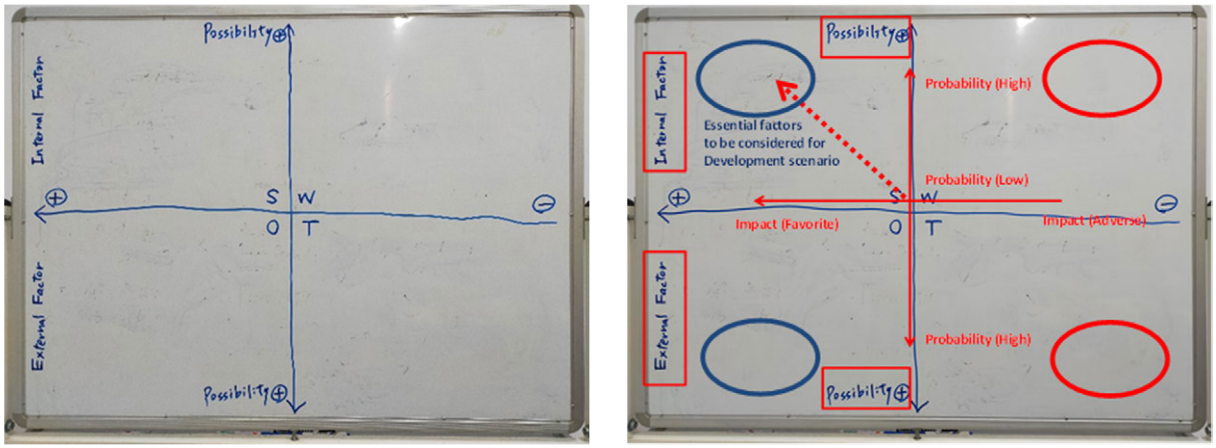
Source: JST

8.2 SWOT Analysis

To formulate a development strategy to solve and improve urban transport issues in Phnom Penh, a SWOT analysis was conducted to analyse the internal factor in terms of "Strengths" and "Weaknesses", and the external factor in terms of "Opportunities" and "Threats". These factors were analysed and considered in proposing development strategies response to changes in the environment after the PPUTMP.

8.2.1 Overview of SWOT Analysis

The environmental factors are classified into SWOT categories by considering the feasibility of each environmental factor and its positive/negative impact on urban transport with respect to the environment. The external factors can be categorised into "direction of urban development," "financial and economic trends," and "technological, environmental, social, and cultural trends" while the internal factors can be categorised into "urban transport management system," "public transport and traffic management," and "road transport". Among the external and internal factors, development strategies were formulated by focusing on the factors with high feasibility and positive/negative impacts.



Source: JST

Figure 8.2.1 SWOT Analysis

8.2.2 External Factors

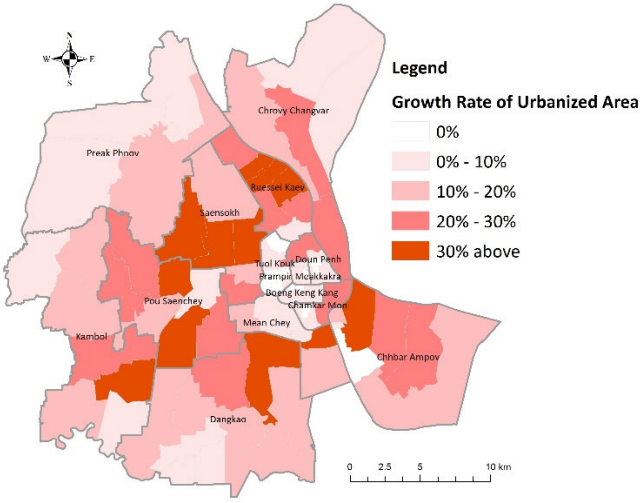
This section summarises the external factors that affect the urban transport issues in Phnom Penh into Opportunities and Threats.

(1) Direction of Urban Development

Phnom Penh was developed artificially and systematically during the French colonisation from 1863 to 1953 as an experimental site for urban and development planning for the relocation of Cambodia's capital to Phnom Penh. The city has been systematically planned, complementing the Mekong and Tonlé Sap Rivers with artificial waterways to secure a logistics network, construction of landmarked colonial architecture, radian streets layout and landmark centred, division of street functions by-cell type development that eliminates through traffic and creating pedestrian space.

From 2008 to 2019, the CAGR of population in CBD was -1.04% while that in non-CBD was 5.52%. In Phnom Penh, there are 101 housing development projects in total, consisting of 54 projects for houses and 47 projects for condominiums.

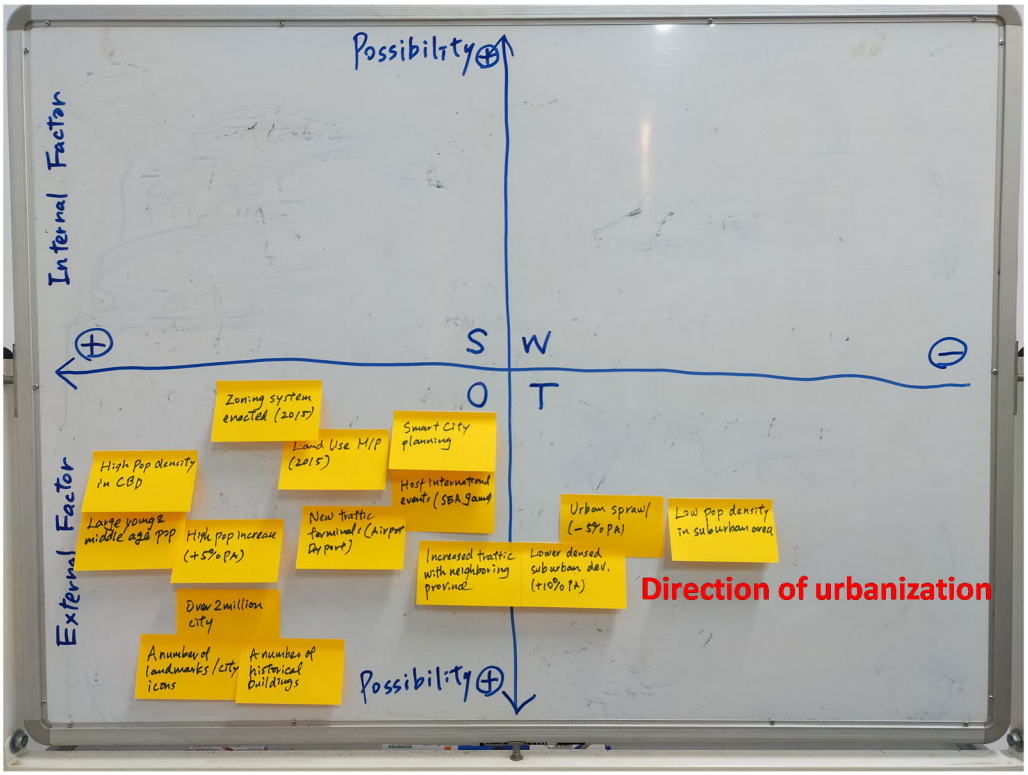
As of 2020, the urbanised area rate of CBD reached 99.5% while that of agricultural area in the outskirts remains 24.7%, which has further development potential. Figure 8.2.2 shows the growth rate of the urbanised area from 2012 to 2022 and identifies active development outside CBD. Therefore, it is assumed that new development will take place outside CBD.



Source: JST based on data of PPUTMP

Figure 8.2.2 Growth Rate of Urbanised Area from 2012 to 2020

[SWOT Analysis] Factors that are highly feasible and expected to have a positive impact on urban transport include “high population density in CBD”, “high percentage of young population and working population”, “high population growth rate of 5% per year”, “many historical buildings and existence of landmarks that symbolise the city”. On the other hand, factors that are expected to have a negative impact on urban transport include “low population density in non-CBD”, “development of low-density suburban areas”, and “further hollowing out of CBD”.



Source: JST

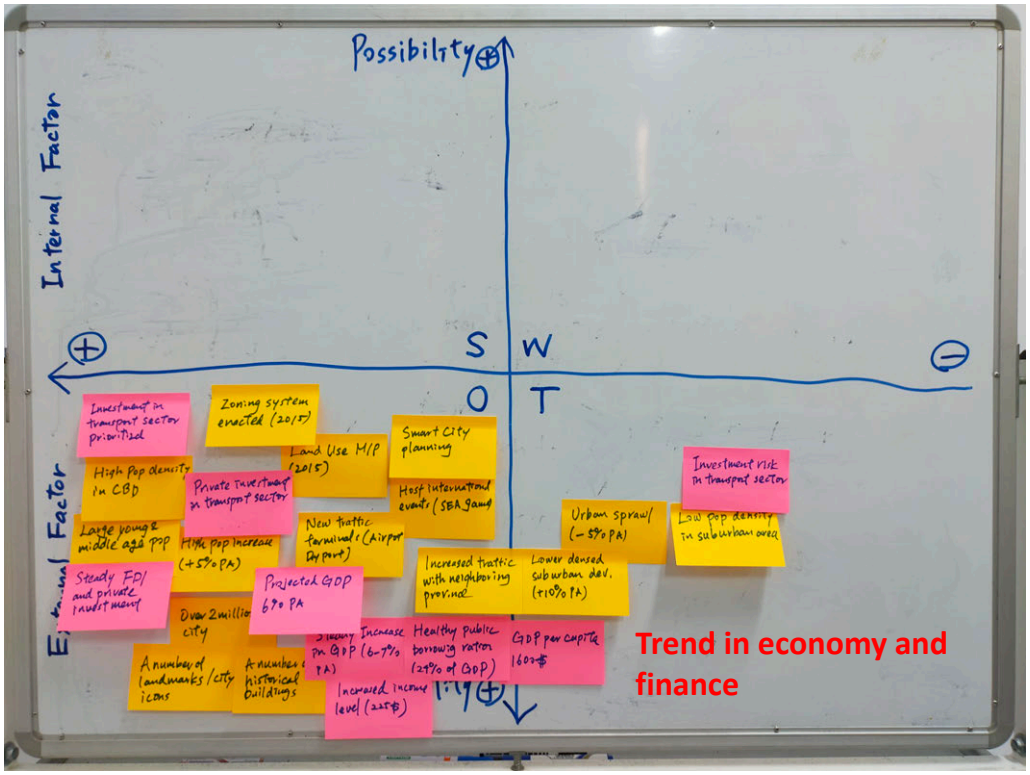
Figure 8.2.3 SWOT Analysis (Direction of Urban Development)

(2) Financial and Economic Trend

As of 2020, Cambodia's public debt is 24% of the GDP and it has been less than 30% in past years. In the "Public Debt Management Strategy 2019-2023", MEF sets the upper limit percentage of the public debt for GDP, which is 55%. The current debt level is less than the half of the upper limit. According to the result of DSA, all five key debt indicators are well below the respective indicative thresholds. This result shows that Cambodia will be able to invest further in domestic infrastructure development.

In recent years, China is investing and providing loans for New Phnom Penh International Airport and Phnom Penh Sihanoukville Expressway. However, the Cambodian government does not provide any loan guarantee for the loans of these entities. On the other hand, in 2019, there are 22 contracts with a governmental guarantee in the electricity service sector by Electricite du Cambodge (EDC). This suggests that RGC recognises that projects in the transport sector have higher risks and the government requests the profitability by themselves.

[SWOT Analysis] Factors that are highly feasible and expected to have a positive impact on urban transport include "strong economic growth and GDP growth" and "strong private investment" despite the COVID-19 pandemic, while factors that are expected to have a negative impact include "investment risks on transport sector and low aggressiveness of investment by government".



Source: JST

Figure 8.2.4 SWOT Analysis (Financial and Economic Trend)

(3) Environment

No areas in Phnom Penh are designated as protected areas such as national parks. Also, there are no laws or regulations for environmental protection. On the other hand, Phnom Penh citizens are struggling with

floods which may occur after even a little rain and cause traffic congestion. This is because of land developments that deteriorated wetlands.

It is projected that the temperature in Phnom Penh will rise by 2°C in average over the next 30 years due to climate change. Also, the heat island effect is expected to increase due to high-density development especially in CBD. Environmental measures for roads and public transport infrastructure on public area is required.

(4) Technology

Mobility as a Service (MaaS) is becoming a dominant trend globally. MaaS provides services of route search, bookings, and payments by integrating various transport modes with information technologies.

According to the CSES (2019/20), 97% of households in Phnom Penh owned a mobile phone in 2019/20. As the ownership rate of mobile phones increased, the use of RHS with tuk-tuk has been expanding in Phnom Penh since 2016.

In addition, electronic payment systems using mobile phones and smart cards have become widespread, and fees are kept low, so there are many users even for small-amount payments.

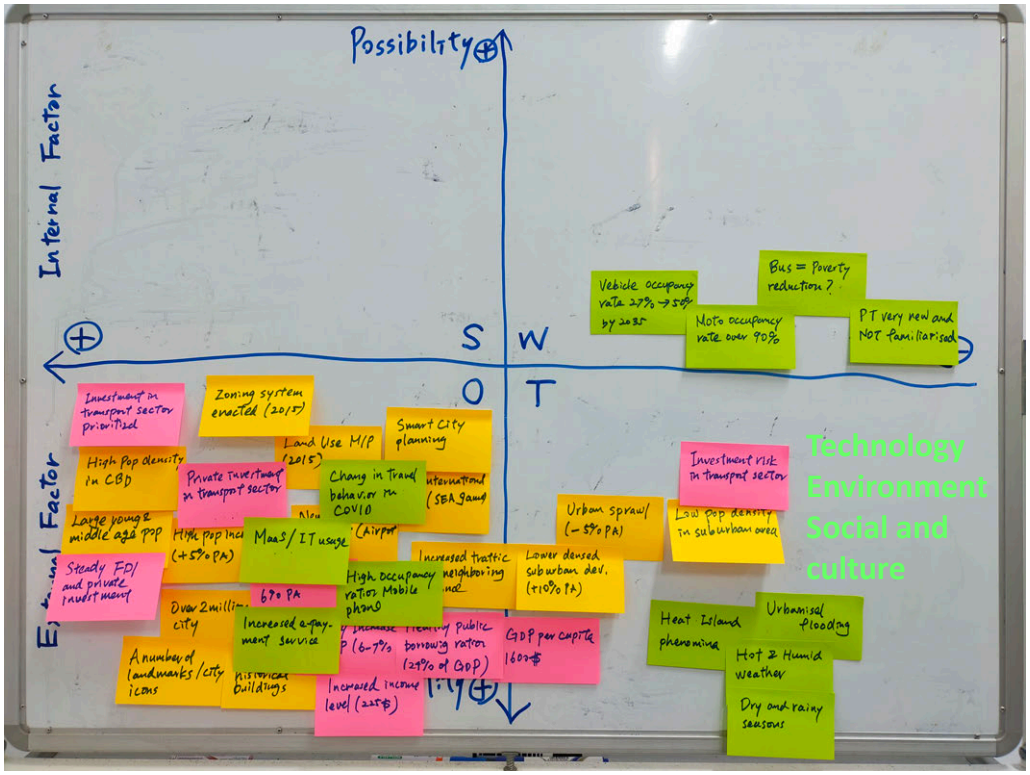
(5) Society and Culture

In terms of public transport, Phnom Penh has a shorter history compared to other Asian cities. Until the City Bus operation started in 2014, citizens needed to rely only on paratransit and private modes of transport. On the contrary, other major cities in Asia such as Bangkok, Jakarta and Manila operated city buses even before 1970. Public transport in these cities transited to urban railway as the passenger travel demand expanded.

The comparison of the CSES in 2014 and 2019/20 suggests that the motorcycle ownership rate in Phnom Penh remains stable at 90%, whereas the car ownership rate increased from 20% to 27%. If this increase rate continues, every household will own a mobile phone and a motorcycle and 50% of all households will own a car in 2035.

Given that Phnom Penh has a shorter history in terms of public transport, further improvement for public transport is required. Otherwise, the urban transport in Phnom Penh will be based on private transport.

[SWOT Analysis] Factors that are highly feasible and expected to have a positive impact on urban transport include “innovation and diffusion of IT technologies such as MaaS (technology)” and “expansion of electronic payment services (technology)”, while factors that are expected to have a negative impact include “urban flooding (environment)”, “hot and humid weather, rising temperatures due to climate change and heat island effect (environment)” and “short history of public transport (society and culture)”.



Source: JST

Figure 8.2.5 SWOT Analysis (Technology, Environment, Society and Culture Trend)

8.2.3 Internal Factors

This section categorises the urban transport challenges in Phnom Penh into Strengths and Weaknesses. Chapter 6 describes the urban transport challenges in detail. With the identified challenges, each internal factor is categorized into SWOT considering the feasibility of each environmental factor and its positive/negative impact on urban transport in terms of “urban transport management system”, “public transport and traffic management” and “road transport”.

(1) Urban Transport Management System

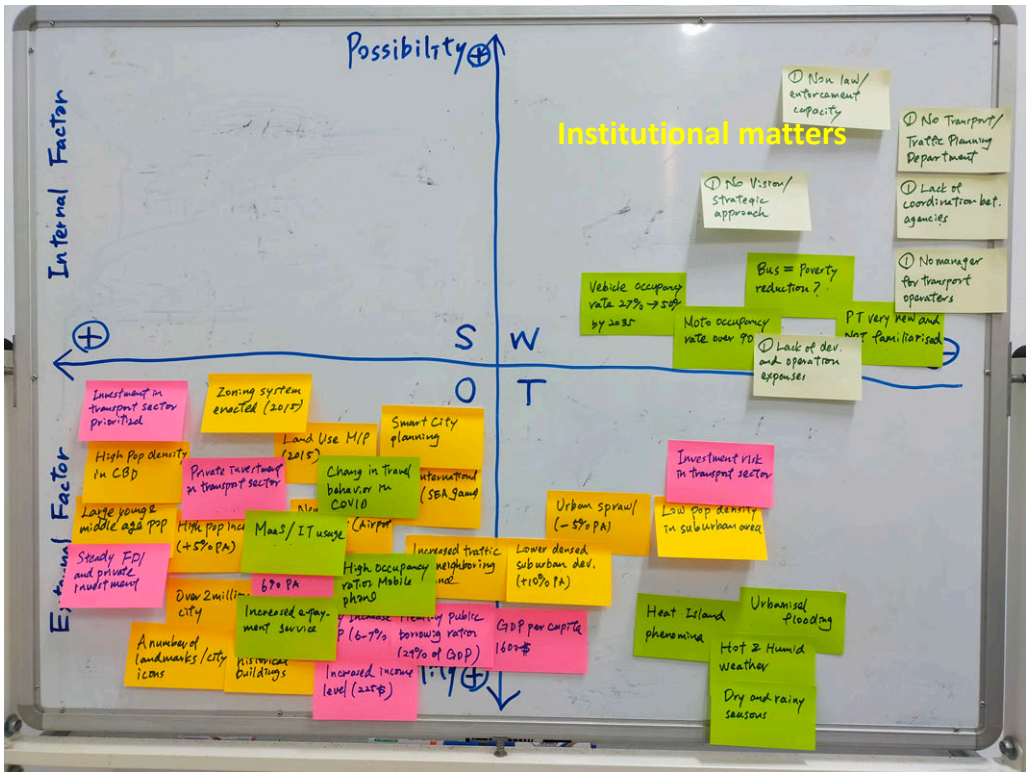
Factors with high feasibility and expected negative impact on urban transport management system include “the absence of coordination function and low coordination capacity among various urban transport related organisations” and “the absence of relevant legal system to manage urban transport or low capacity to enforce these laws”.

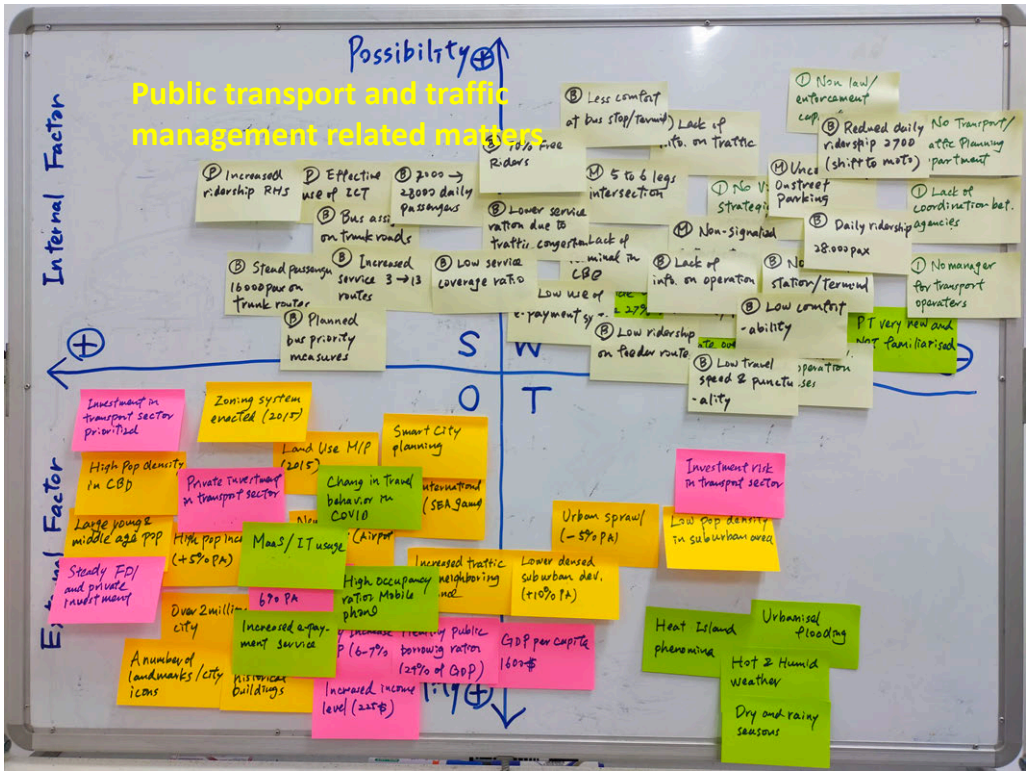
(2) Public Transport and Traffic Management

With regard to public transport and traffic management, factors with high feasibility and which are expected to have a positive impact on urban transport include “expansion of bus routes and a certain number of users on trunk routes” and “high utilisation of the RHS”. On the other hand, factors expected to have a negative impact include “suspension of bus service due to the COVID-19 pandemic and sluggish return of users after the resumption of bus service”, “low punctuality and rapidity of bus service due to traffic congestion”, and “lack of information on bus service”. Note that "high utilization of the RHS" is categorized as a positive impact due to the high modal shift potential to public transportation.

(3) Road Transport

Factors that are highly feasible and expected to have a positive impact on road transport include “continuous improvement of road infrastructure”, “low car ownership rate”, “progress of cell-type traffic urban development and town block formation” or “clarification of the division of road functions associated with such development”. On the other hand, factors that are expected to have a negative impact include “inadequate standards for street planning, design and maintenance”.





Source: JST

Figure 8.2.6 SWOT Analysis (Urban Transport Management System, Public Transport and Traffic Management, Road Transport)

BOX 6 : Traffic Management Measures in Singapore

Immediately after the independence in 1965, the traffic congestion issue became more serious as the economy developed in Singapore. In 1987, the Mass Rapid Transit, MRT, started operation and the public transportation network was formulated gradually. Therefore, Singapore government has started to control the total amount of vehicles in Singapore with Vehicle Quota System. In the system, all the vehicle owners are required to obtain a Certificate of Entitlement (COE). The total number of COEs to be issued is fixed, and the price is determined by bidding. As of January 2023, COE costs about S$ 80,000 (about 7.77 million yen) for car of 1600cc or less for 10 years. The high cost of COE decreases the demand of vehicle ownership.

In addition, there are restrictions on the daily use of car. An Electronic Road Pricing, ERP, system that charges when a car passes through a certain area or route, and an off-peak car system that requires the purchase of a license to drive during the daytime on weekdays, etc. have been introduced. Illegal parking is also cracked down by CCTV cameras in addition to the traffic police. Also, there are unique fine for illegal parking such as a fine of S$70 to S$110 for parking within 9 meters of a bus stop. Regarding illegal parking, a mobile phone app has also been introduced that allows roadside residents to post illegal parking.

Source: Ministry of Transport, Singapore

Figure 8.2.7 Pricing Gate for ERP in Singapore

Source: Singapore Government Agency

Figure 8.2.8 Illegal Parking Posting App.

8.3 Formulation of New Conceptual Strategy for Urban Transport

8.3.1 Perspectives for New Strategy Formulation

With SWOT Analysis, the internal factors are classified into two categories: Strengths and Weaknesses. The external factors are classified into two categories: Opportunities and Threats. New conceptual strategy for urban transport is formulated and proposed from the viewpoint of, “Integrated Strategies” to further exploit the strengths and overcome the weaknesses of the internal factors, “Proactive Strategies” to further develop the strengths by identifying highly feasible external opportunities, and “Reactive Strategies” to further develop the strengths by identifying progress in external threats.

Source: JST

Figure 8.3.1 Perspectives to Formulate the New Conceptual Strategy for Urban Transport based on SWOT Analysis

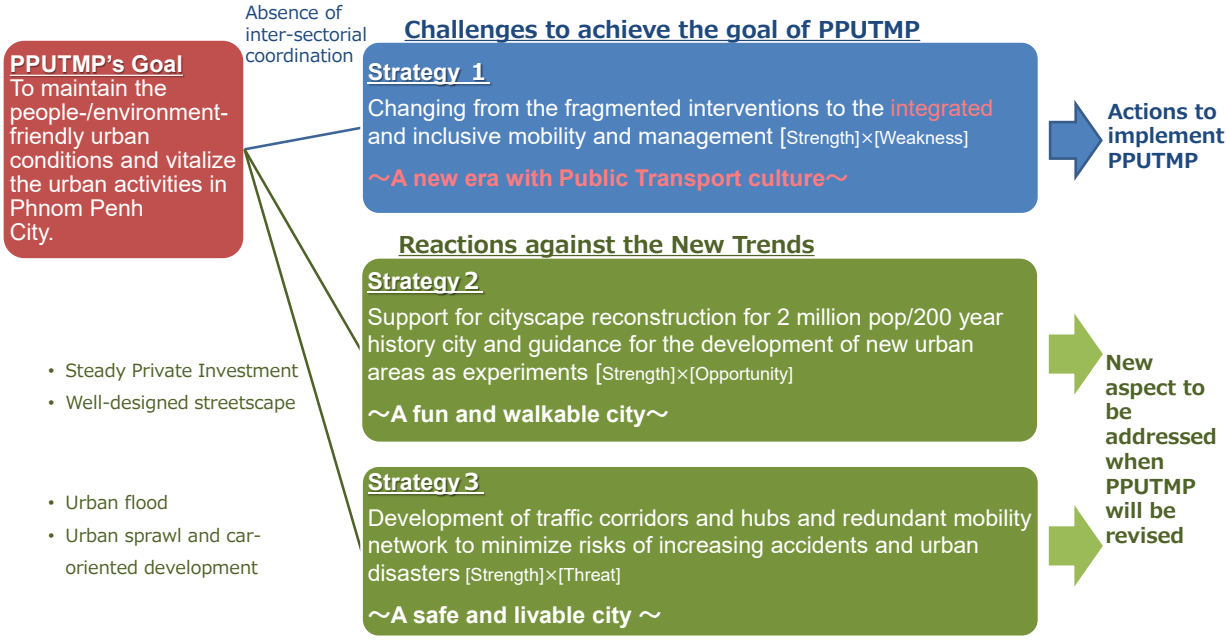
8.3.2 Formulation of New Conceptual Strategy for Urban Transport

(1) Target Year of New Urban Transport Strategy

The target year for the urban development strategy is set as 2035 in accordance with PPUTMP.

(2) Draft New Conceptual Strategy for Urban Transport

The draft new conceptual strategy for urban transport based on the analysis of the internal and external factors through SWOT analysis and the perspective of strategic planning based on the pillars of "integrated strategy," "proactive strategy," and "reactive strategies" is shown in the figure below.



Source: JST

Figure 8.3.2 Draft New Conceptual Strategy for Urban Transport

1) Integrated Strategy: Changing from the fragmented interventions to the integrated and inclusive mobility and management -A New Era with Public Transport Culture-

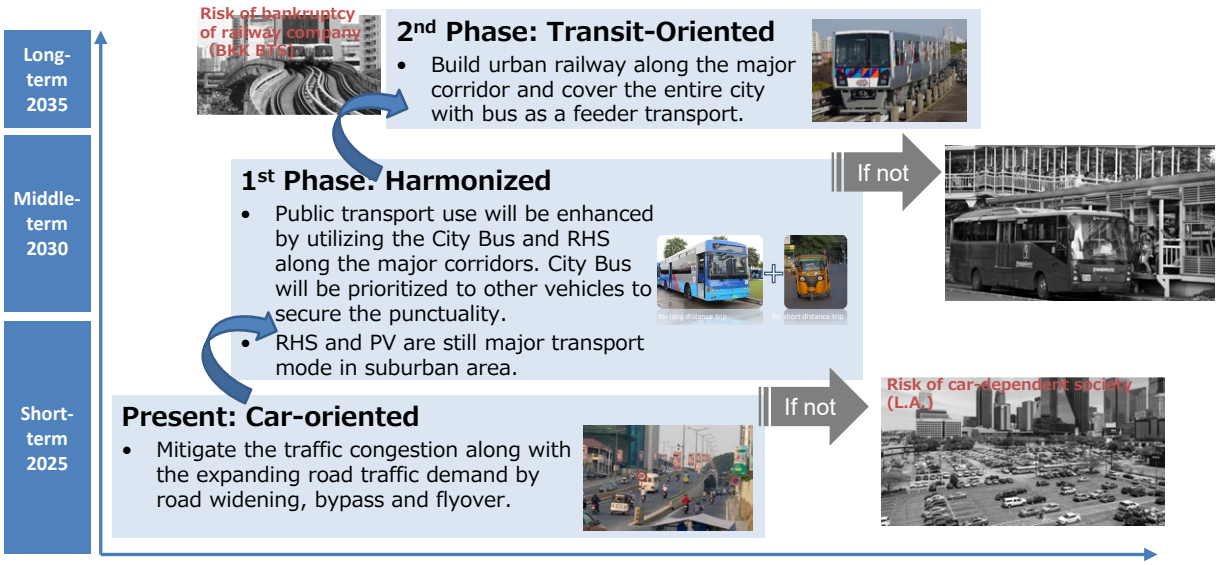
a) Strengthen Coordination Mechanism among Urban Transport Related Agencies

After the formulation of the PPUTMP, several efforts have been made by the PPCA and other implementing agencies to improve urban transport such as the construction and widening of urban roads, installation of traffic signals and operation of city buses as recommended in the PPUTMP. However, these efforts have been fragmented and have yet to result in the behavioural change in the city's residents that the PPUTMP aimed for, such as a shift from private to public transport.

Therefore, a framework for effective utilisation of urban transport infrastructure should be established, including the creation of an Urban Transport Management Bureau (tentative name) to strengthen coordination among various related agencies, planning of various short-term urban transport measures in priority corridors, and implementation of the short-term measures of road, public transport and traffic management along these priority corridors while coordinating with related agencies under this bureau.

b) Draft Development Scenario to Achieve the Goals of PPUTMP

Currently, major measures against the rapidly increasing traffic demand are road widening and bypass road developments that are relatively inexpensive and fast-acting. But it may promote further car dependency and parking space in future. It will damage the historic cityscape in Phnom Penh. In terms of public transport, Cambodia has a shorter history. To achieve the 35% public transport share by 2035 as recommended in the PPUTMP and to establish a public transport culture, it is necessary to shift from the current car-oriented development to create the public transport culture with punctual bus network and walkable sidewalk. It will continue to the development of mass transit in major corridors in the future.



Source: JST

Figure 8.3.3 Draft Development Scenario to Achieve the Goals of PPUTMP

1st Phase: Harmonised

Until mass transit is developed in the medium term, a public transport culture should be created by utilising existing bus transport and RHS. As the 1st Phase, punctuality and rapidity are ensured by bus priority lanes along the major corridors. It secures the high quality of public transport service by being integrated with feeder networks such as RHS and mini-buses. Public transportation culture will be created along the major corridors.

At present, buses and RHS are in a competitive relationship. However, it is necessary to promote coordination. Large buses will be responsible for the transportation of arterial roads and, RHS and minibuses will be responsible for the transportation in the missing areas of public transport within the city and suburban area where large buses cannot pass.

A coordination mechanism will be established among the concerned agencies including private transport operators, PPCA, MPTW and RHS companies, etc. Traditional culture of sidewalk privatisation and illegal parking is required to be changed.

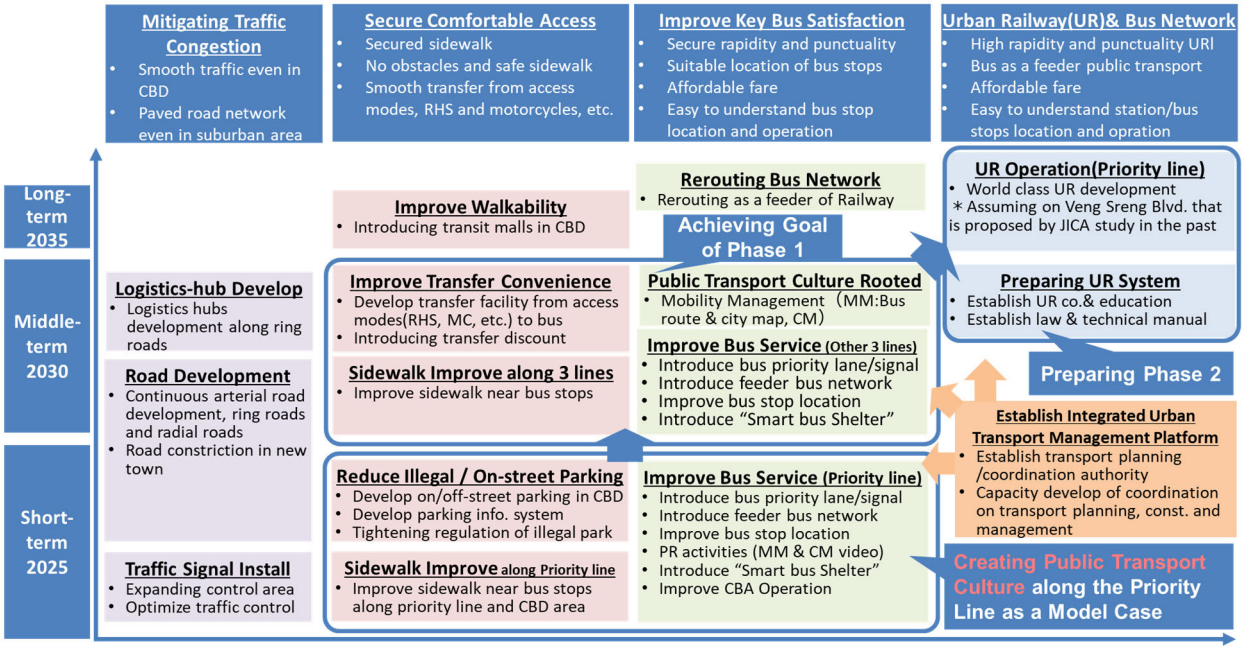
2nd Phase: Transit Oriented

As the 2nd phase, urban railways will be developed along the major corridors. It ensures punctuality, rapidity and transport capacity. High quality of public transport service is ensured in the entire city by formulating the public transportation network integrating the urban railways with the feeder network.

It is necessary to create a mechanism to ensure the financial feasibility of the urban railway business such as commercial area development at stations, etc. Considering the suspended airport railways and commuter railway projects in the past, a high quality of urban railway that greatly exceeds the service level of existing transportation modes (cars, motorcycles, RHS) and changes the image of public transport in Cambodia is required. Appropriate design and management are required at each stage of planning, construction and operation of urban railway.

c) Transport Sector Improvement Programmes and Time Frame to Achieve the Goal of PPUTMP

The following figure shows the transport sector improvement programmes and time frame to achieve the goal of PPUTMP.



Note: The priority route (Veng Sreng Blvd.) and the other three routes in the figure were selected in "Support for Sustainable and Integrated Urban Public Transport Development (ADB Survey)" shown in Figure 4.4.3.

Source: JST

Figure 8.3.4 Transport Sector Improvement Programmes and Time Frame to Achieve the Goal of PPUTMP

2) Proactive strategy: Support for reconstruction of the cityscape appropriate for Phnom Penh, a city with 200 years of history and 2 million inhabitants, and guidance for the development of a new urban area as experiments - A Fun and Walkable City-

As mentioned above, Phnom Penh Capital was relocated from Udon, the capital during the French colonial period, to the current Phnom Penh in 1866. With a population of only 10,000 at the time of the relocation, the city was constructed artificially and systematically. Colonial-style buildings were constructed to serve as landmarks, and city blocks radiating from the landmarks were formed. Today, these historical buildings and streetscapes are still preserved, and the private sector is leading the development of a series of cellular housing developments in the suburban areas.

In the 200-year history of urban development in Phnom Penh, the streetscape that was artificially created as an experimental site for urban development during the French colonial period has been inherited by the cellular residential development still underway in the suburban area, and in terms of traffic, the streets have been divided into different functions, elimination of through traffic and creation of walking space.

In 2015, the PPCA formulated the "Land Use Master Plan 2035 in Phnom Penh Capital City (PPLUMP)," and in accordance with this land use plan, it will regulate uses, designate building-to-land ratios and floor area ratios, and issue building permits. In conjunction with such urban development, the M/P for Urban Transport will be reviewed in accordance with the land use plan, and standards for

planning and designing streets will be established and applied, with the slogan of "A Fun and Walkable City". It is also expected to guide the development of new urban areas in the suburban areas.

Source: JST

Figure 8.3.5 A Shophouse Built in the City Centre during the French Colonial Era (Left) and a Typical Cell-type House Development Built in the Suburbs (Right)

BOX 7: National Seminar on the Preservation of Urban Heritage in Cambodia (2006)

For two days on January 16th and 17th, 2006, the Governor of Phnom Penh, UNESCO representatives, and Cambodia-related ministries and agencies participated in discussions on the conservation of historic buildings in Phnom Penh. The following declaration was made;

1. We acknowledge built environments and realised architectural concepts may be regarded as forming an irreplaceable universal heritage.
2. We support historic areas and buildings which are considered significant should be protected against any change which would impair their authenticity and endorse the UNESCO's recommendations and related activities,
3. We support the development of statements and strategies which set out how urban heritage can be integrated into the development of towns and cities and be a clear connection between the past and future,
4. We support the implementation of these objectives through the establishment of heritage conservation plans at local and regional levels, to act as guidelines for development.
5. We recognise the progress and achievements in the developing of master plans and support the integration of urban heritage issues by the inclusion of heritage conservation plans.

At the conference, efforts related to the conservation of the Central Market and the Central Post Office were introduced as an example of the conservation of historic buildings in Phnom Penh.

Central Market:

Designed by French architects during the French Colony, built in 1937, and rebuilt in 2011 with the same design with the support of the French Development Agency.

Central Post Office:

Also designed by French architects during the French Colony and built in 1895, and rebuilt in 2004, following the original design.

Table 8.3.1 New Conceptual Strategy for Urban Transport and Transport Improvement Projects in the Short and Medium Term (Draft) 1

New Conceptual Strategy	Transport Improvement Plans / Programmes against the New Trends
[Proactive Strategy] Support for reconstruction of the cityscape appropriate for Phnom Penh, a city with 200 years of history and 2 million inhabitants, and guidance for the development of a new urban area as experiments **- A Fun and Walkable City-**	• Formulation of Transport M/P based on new land use plan • Formulation and operation of Street design guide/standards • Legalisation and operation of traffic assessment • Development and operation of legal frameworks for private financed transport infra., sidewalk, public transport and parking space, development • Parking management, including trucks, in CBD • Pedestrian network plan in CBD, etc.

Source: JST

3) Reactive Strategies: Development of Traffic Corridors and Hubs and Redundant Mobility Network to Minimise Risks of Increasing Accidents and Urban Disasters

The topography of the Phnom Penh metropolitan area is generally flat, with a gentle slope from north to south and from west to east, and flood plains at an elevation of approximately 4 m along the Tonlé Sap, Bassac, and Mekong Rivers. Although the area has drainage and water storage functions during the flood season, including a ring dike in the urban centre, the wetlands and lakes around Phnom Penh in recent years are currently being reclaimed for development, and the decline in water storage functions is contributing to the increase in urban flooding. Furthermore, the risk of urban disasters is expected to increase in the future due to rising temperatures associated with climate change, the emergence of the heat island effect, and the combination of these factors with torrential urban rainfall, etc. The impact of these disasters on the movement of people and goods within the city is a concern.

Therefore, while confirming the progress of these urban disaster threats, this Strategy proposes to gradually strengthen urban transportation infrastructure. It is expected that the city's road network and public transport network will be considered as part of the city's infrastructure, and in preparation for upcoming urban disasters, preparations will be made to support safe and secure lifestyles by designating disaster prevention and environmentally vulnerable areas, establishing evacuation sites and routes, and developing emergency transport networks.

Table 8.3.2 New Conceptual Strategy for Urban Transport and Transport Improvement Projects in the Short and Medium Term (Draft) 2

New Conceptual Strategy	Transport Improvement Plans / Programmes against the New Trends
[Reactive Strategies] Development of traffic corridors and hubs and redundant mobility network to minimize risks of increasing accidents and urban disasters	• Traffic corridors and hub development in disaster prevention and environmentally vulnerable areas (Green belt, pocket park, evacuation area/access, multi-layered evacuation routes/means, etc.) • Spatial segregation, zoning, between logistics hubs and residential areas. • Emergency transport planning/network development • Traffic safety measures and training/education, etc.

Source: JST

Chapter 9 Implementation Plan

9.1 Implementation Plan

9.1.1 Implementation Plan

Concrete project plans based on the development scenario in Chapter 8 for realising the PPUTMP and for reacting against the new trends, their phases to be implemented and the assumed executing agencies are summarised in Table 9.1.1.

Table 9.1.1 Implementation Plan for Realising PPUTMP and for Reacting against New Trends

Programme	Phase	Executing Agency (Underlined) / Concern Agency
Strategy 1: Changing from the fragmented interventions to the integrated and inclusive mobility and management		
1. Strengthen Coordination Mechanism among Urban Transport Related Agencies		
Establish Integrated Urban Transport Management Platform • Establish transport planning / coordination authority To strengthen coordination functions related to urban traffic, Integrated Urban Traffic Management Platform (IUTMP) will be formulated in the PPCA A transportation planning and coordination agency shall be established in future. • Develop coordination capacity on transport planning, construction and management Through discussions among the IUTMP regarding the revision of the PPUTMP and the actual planning and implementation of projects such as the buses priority lanes, the coordination mechanism on urban transport will be improved.	Short-term	PPCA, MPWT, DPWT, CBA, TCC, Traffic Police
2. Improve Key Bus Satisfaction		
Dedicated/Priority Facilities for Bus • Introduce bus dedicated/priority lane Dedicated and priority lanes for buses will be introduced on the 4 main routes (city bus Lines 1, 2, 3 and 4A) proposed in the ADB study (see 4.4.5). • Introduce bus dedicated/priority signal Existing traffic signals on the 4 major routes mentioned above will be upgraded to bus priority signals.	Short/Mid-term	PPCA, DPWT, CBA, TCC
Improve Bus Service To improve the management of CBA and secure the stable financial resources, public transport priority measures such as making CBA a public administrative enterprise, reviewing the subsidy and fee system and introducing bus dedicated /priority lanes will be planed and implemented.	Short	CBA, PPCA
Introduce “Smart Bus Shelter” To improve the comfortability, convenience and safety of users at bus stops, smart bus shelters will be installed on major bus routes.	Short/Mid-term	PPCA, DPWT, CBA

Programme	Phase	Executing Agency (Underlined) / Concern Agency
Introduce Feeder Bus Network To improve the convenience of buses, the bus network will be expanded beyond major highways. It is required to increase the number of buses and strengthen the operation system. Procurement of minibuses will also be considered since some roads are too narrow for large buses.	Short/Mid-term	PPCA, CBA
Mobility Management To create a culture of public transport, user interview surveys and public awareness campaigns, spreading information on public transport and the introduction of car-free days will be conducted.	Short/Mid-term	PPCA, CBA
3. Secure Comfortable Access		
Improve Sidewalks Constructing the paved sidewalks to bus stops. In particular, secure a safe and comfortable pedestrian route from the residential area to the bus stop since some of narrow roads are not paved and there are no sidewalks in some roads around residential areas.	Short/Mid-term	DPWT, PPCA, Khan
Improve Transfer Convenience • Develop transfer facility from access modes (RHS, MC, etc.) to bus To improve transfer convenience, parking spaces for RHS and motorcycles will be developed at the terminal bus stops and near the intersections of main roads and bus routes. • Introduce transfer discount A discount system will be introduced for users who use buses as trunk transport mode and RHS as access transport mode. At present, CBA and RHS companies have different fare payment systems. In future, they should be integrated.	Short/Mid-term	PPCA, DPWT, CBA, RHS Companies
Develop Parking Facilities • Develop on-street parking facilities in CBD Developing on-street parings at the roads in the city centre where illegal parking chronically blocks the roads and car can pass through only in one direction as of today. • Develop off-street parking facilities in CBD Off-street parking lots will be developed in vacant area and underground areas of roads where parking demand is high.	Short-term	DPWT, PPCA Private Parking Owners
Develop Parking Information System Develop an information platform that provides the information on public / private on/off-street parking locations, fees and availability in order to maximize the use of existing parking lots.	Short-term	DPWT, PPCA Private Parking Owners
Tighten Regulation of Illegal Parking To strengthen crackdowns on illegal parking by increasing the number of traffic police, introducing vehicle cameras for illegal parking monitoring and introducing a reporting system for roadside residents. It should be also considered to increase fines for illegal parking near bus stops. Regarding illegal parking on sidewalk, regulations and rules will be clarified through the enactment of the Parking Law.	Short-term	Traffic Police, MoI, MPWT

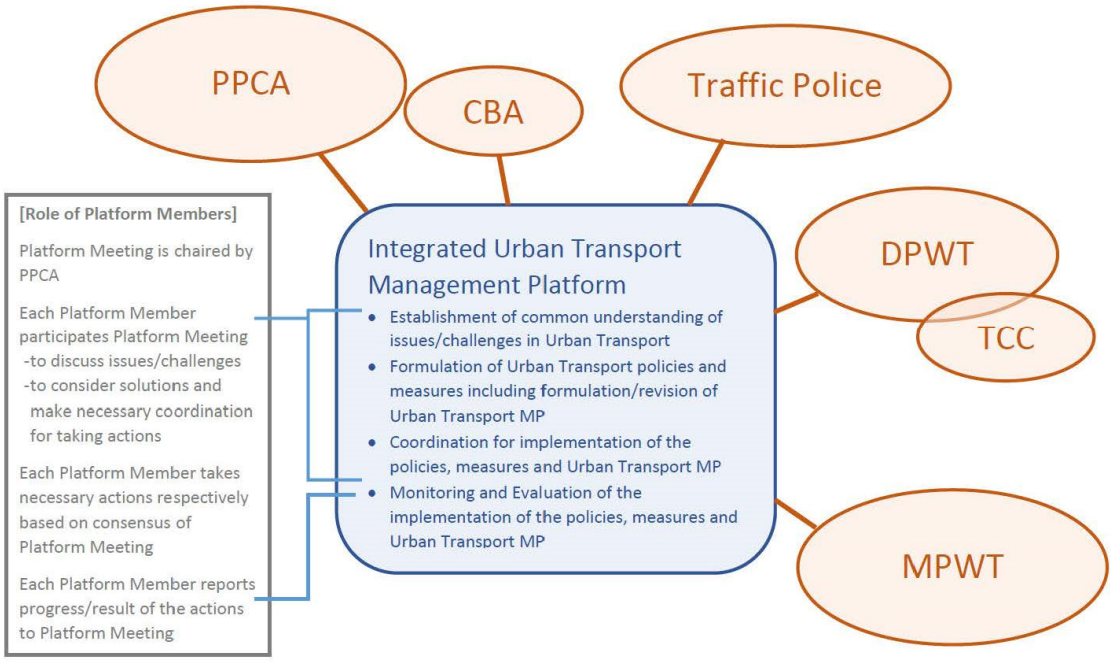
Programme	Phase	Executing Agency (Underlined) / Concern Agency
4. Mitigate Traffic Congestion		
Install/improve Traffic Signal • Expand signal control area Currently, wide area traffic signal control is conducted in CBD area. It will be expanded by installing signals and connecting them to the control system in suburban areas. • Optimize traffic control Utilizing traffic big data obtained from existing CCTV and vehicle detectors, the traffic control parameters such as split and cycle of traffic control are optimized to maximize the traffic capacity of existing intersections and roads.	Short-term	TCC, PPCA, DPWT
Develop Road Network • Develop arterial roads (ring roads and radial roads) 2nd and 3rd ring roads will be developed. Major radial roads will be widened. Access road to new airport access will be developed. • Construct roads in new town Urban development by the private sector is progressing in the suburbs. Roads in the new urban area and access roads to main roads will be developed in cooperation with urban development companies.	Short/Mid-term	MPWT, DPWT, PPCA
Develop Logistics-hub (Truck Terminal) Considering the land use plan and the development plan for the ring roads, truck terminals will be developed at the logistics-hubs.	Mid-term	MPWT, DPWT, PPCA
5. Develop Public Transport Network by Urban Railway and Bus		
Legal Preparation for Urban Railway Development • Establish urban railway operation company To develop the urban railway in future, urban railway operation company shall be established. • Establish laws and standards for urban railway To develop and operate the urban railway, legal frame and technical standards will be established.	Mid-term	MPWT
Develop Urban Railway Construct the urban railway. It is assumed that the railway will be installed along the Veng Sreng Blvd. due to the large traffic demand from the city centre to the west were observed in transport surveys. It is necessary to confirm the final route, mode and operation scheme through F/S.	Long-term	TBD
Strategy2: Support for cityscape reconstruction for 2 million pop/200 year history city and guidance for the development of new urban areas as experiments		
Formulation of Transport M/P based on new land use plan Considering the current land use plan, PPLUMP, and the urban development policy in the latest land use plan which is currently being discussed for revision, PPUTMP will be revised.	Short-term	PPCA, MLMUPC, MPWT, DPWT, CBA, TCC, Traffic Police
Formulation and operation of Street design guide/standards To guide and control the private sector in developing a safe and comfortable street, guidelines and standards for developing street will be formulated.	Short-term	PPCA, DPWT
Legalisation and operation of traffic assessment Establish and operate a traffic assessment system that requests to assess the impact of constructing large-scale commercial facilities and urban development on the traffic environment in advance and implements necessary preventive measures by the private developers.	Mid-term	MPWT, PPCA, Traffic Police, MoI

Programme	Phase	Executing Agency (Underlined) / Concern Agency
Development and operation of legal frameworks for private financed transport infra., sidewalk, public transport and parking space, development Enact standards for the installation of streets, public transportation, parking lots, etc. in private urban development.	Mid-term	PPCA, MPWT, DPWT
Parking management, including trucks, in CBD Government, residents, transportation operators, traffic police, etc. will work together to formulate a parking management plan in CBD. Shared parking space, cargo handling spaces and regulation the time of vehicle inflow will be developed based on the plan.	Mid-term	PPCA, MPWT, DPWT, Traffic Police
Pedestrian network plan in CBD Targeting the heart of the CBD, pedestrian network plan that connect public transportation networks with major commercial and tourist spots will be established. Sidewalk environment will improved.	Mid-term	PPCA, DPWT
Strategy3: Development of traffic corridors and hubs and redundant mobility network to minimize risks of increasing accidents and urban disasters		
Traffic corridors and hub development in disaster prevention and environmentally vulnerable areas (Green belt, pocket park, evacuation area/access, multi-layered evacuation routes/means, etc.) To assess the risks against urban disasters such as floods, plan and develop disaster prevention centres and evacuation routes.	Long-term	PPCA, DPWT
Spatial segregation, zoning, between logistics hubs and residential areas. To improve the traffic safety for residence and the convenience of trucking companies, logistics area and resident area will be spatially separated coordinating with the land use plan.	Long-term	MPWT, PPCA, MLMUPC
Emergency transport planning/network development To secure the logistics system during the disasters, an emergency transportation network plan will be established and implemented. Emergency logistics plan and organization for countermeasures against disaster with public-private partnerships will be established.	Long-term	MPWT, DPWT, PPCA
Traffic safety measures and training/education, etc. Improving the capacity on investigation, analysis and countermeasure on traffic safety and the capabilities on traffic enforcement. Installing road markings and signs, and carry out traffic safety campaigns and education.	Short-term	Traffic Police, MPWT, DPWT, PPCA

Source: JST

9.1.2 Organisation and System

For effectively and efficiently implementing the policies and measures for improving urban transport in Phnom Penh, JST proposes establishing the Integrated Urban Transport Management Platform in PPCA, which coordinates for implementing them. In the Platform, urban transport related issues and solutions are discussed and necessary coordination, information sharing and budgeting are made. The platform meeting consists of MPWT, DPWT, CBA, TCC and Traffic Police and chaired by PPCA. Concern ministries and agencies, such as MEF, MLMUPC and MoI, and donor agencies that are cooperating in the urban transportation sector will also participate in the Platform as observers as necessary. It can share a common understanding of issues and countermeasures related to urban transportation among stakeholders.



Source: JST

Figure 9.1.1 Integrated Urban Transport Management Platform

9.2 Consideration for Future Cooperation in Urban Transport Sector

Based on the urban transport improvement policy of the PPUTMP, which was formulated in 2014 with support from JICA, some urban transport improvement projects have been implemented, such as road improvement and the start of bus service. However, the PPUTMP is not linked to the long-term budget plan of Cambodia government since the PPUTMP isn't officially approved planning document. It's urgent for PPCA to revise and approve the PPUTMP as an official document using the latest traffic data and link it to the long-term budget plan. However, it should be noted that the approval process for urban transport M/P is not established in the legal system of Cambodian.

The existing PPUTMP has five strategies by transport subsector. On the other hand, three cross-sectoral strategies were proposed as a draft strategy for the revision of PPUTMP in this study. The new strategies considering the realization of comprehensive and inclusive mobility and management and the two new perspectives such as reconstruction of historical townscapes and disaster management. In particular, the "Project for Development of Integrated Urban Transport Management Mechanism in Phnom Penh Capital City" was proposed as a priority project to establish an Integrated Urban Transport Management Platform (IUTMP) and to strengthen coordination capacity, as it is essential to strengthen the coordination capacity of multiple agencies related to urban transport in order to efficiently improve urban transport under budgetary constraints. The PPCA also plans to establish a PMU chaired by the Governor of Phnom Penh to revise the PPUTMP and strengthen the coordination function in the field of urban transportation. Therefore, it is necessary to monitor the establishment of the PMU. To ensure the effectiveness of the revised PPUTMP, it is necessary to involve the MEF and MPWT in the process of revising the PPUTMP. It is also important to involve relevant ministries, agencies, and donor agencies as observers of the PMU and IUTMP. In addition, it is necessary to include not only the PPCA but also the Kandal Provincial Government since the traffic demand for commuting from Kandal Province is increasing.

The PPUTMP had a goal of increasing the public transportation share to 30% by 2035 with developing four

urban railways. However, the results of the transportation survey conducted in 2022 in this study revealed that the target level needs to be revised since the modal share of public transport remains low and it will take time to develop urban railway. Therefore, this study proposed a development scenario by phases. Firstly, a public transportation culture shall be created as a pilot project, mainly along the priority route. Then, the culture shall be expanded to the entire metropolitan area.

In the application form submitted by the Cambodia government on the "Project for Development of Integrated Urban Transport Management Mechanism in Phnom Penh Capital City", several activities were included such as, (Activity 1) the establishment of the IUTMP, (Activity2) the revision of the PPUTMP, (Activity 3) the improvement of the public transport system and (Activity 4) the preparation of guidelines for the strategic application of transport measures. It is necessary to further narrow down the scope of activities while taking into consideration the duration of the study and the budget constrain. During the process, JST proposes to focus on specific area along the priority corridor and implementing pilot initiatives to promote the use of public transportation, while seeking synergy with the support provided by other donors such as ADB. It can create a public transportation culture in the priority area. For example, the pilot project could include the development of transit facilities, tighter parking regulations, and a parking information system. Those pilot projects would have synergistic effects with the development of priority lanes for buses, which is being considered for ADB support, sidewalk improvements, which is being considered for US support, and the pilot project of smart bus shelters being implemented by MLIT Japan.

To revise the PPUTMP, PPCA conducted the "Phnom Penh Urban Transport Master Plan Revision Work" shown in 4.4.1, but it does not include quantitative analysis such as traffic surveys, etc. On the other hand, the latest traffic data was collected in this study and it should be used for the process of the PPUTMP revision. The evidence based discussion with the traffic data accelerates the coordination among the relevant organizations. Furthermore, it is recommended to use the procedures and exampled in the urban public transport policy guides and the planning toolkit developed in SSIUPTD (see 4.4.5) as a reference in revising the PPUTMP.

Table 9.2.1 Comparison of Assumptions, Development Policies, and Implementation Mechanisms between the PPUTMP and the Revised PPUTMP (draft)

		Assumptions and development policy for formulating PPUTMP	Assumptions and development policy for revising PPUTMP (Draft)
External/ internal factors	Society and Culture	The population of Phnom Penh is estimated to be 2.4 million in 2020. The car-owning household rate is estimated to be 24% in 2020.	The population of Phnom Penh will reach 2.28 million in 2019, nearly the PPUTMP estimate. The car-owning household rate reached 27% in 2020, increasing faster than the PPUTMP's assumption.
	Urban Development Policy	It is assumed that by 2020, redevelopment of CBD and large-scale urban development in suburban areas will have progressed.	Large-scale development is progressing in both CBD and suburban areas. Population is declining in the CBD and increasing in the suburban areas. Large-scale urban and transportation infrastructure is also being developed in Kandal Province.
	Environment	Increased traffic will cause further air pollution.	In addition to the air pollution caused by increased traffic volume, the reclamation of wetlands and lakes around the Phnom Penh has reduced their storage functions and increased urban flooding.

		Assumptions and development policy for formulating PPUTMP	**Assumptions and development policy for revising PPUTMP (Draft)**
	Finance	To develop large-scale urban transportation infrastructure such as urban railways.	The introduction of urban railways with public funds has been suspended. Considering the current traffic condition in Phnom Penh, it is necessary to introduce the urban railway system.
	Technology	-	The RHS is expanding due to the growing popularity of mobile phones. Electric vehicles are expanding globally.
Development Goal		Support and develop the vitality of the capital city (active economic activity) and a people- and environment-friendly urban environment (affluent civic life)	
Strategy		Strategies are proposed for each of the five transportation subsectors (public transportation, roads, traffic management, logistics, and environmental and social considerations).	Three cross-sectoral strategies are proposed. To achieve comprehensive and inclusive mobility and management. Additionally, two new perspectives such as the restoration of historical townscapes and disaster management are considered.
Development Scenario	Short-term (2020)	• Construction of ring / radial roads • Improve comfort of pedestrian space • Improve mobility of residents by introducing public transportation • Support and guide urban development in suburban area • Improve transportation network in large-scale development area in suburb	• Construction of ring / radial roads • in progress • The city bus service has started, but the modal share of public transportation remains low due to low punctuality and limited service coverage area. • Urban development by private investment is progressing, but public guidance and support are not sufficient.
	Mid-term (2025)	• Construction of ring / radial roads • Improve mobility of residents by introducing public transportation • Support and guide urban development in suburban area (roads, public transportation) • Support and promote relocation and consolidation of logistics and production facilities	• Strengthen transportation planning and coordination functions. • Create a public transportation culture by using the priority routes as a model case by harmonized development of buses and RHS. Ensure a comfortable access environment and improve satisfaction with key bus services. • Continue to develop a ring / radial roads.
	Long-term (2035)	• Promote and support redevelopment of CBD integrated with transportation nodes and new urban development in suburban areas with TOD • Improve mobility of residents by introducing public transportation	• By 2030, public transport culture will be establised along four major bus corridors. • Promote TOD development with urban railways and feeder buses. • Develop a fun and walkable city. • Strengthen the urban transportation infrastructure.
Implementation Mechanism	Regulation	There was a discussion to approve PPUTMP during the project period. However, the approval process was suspended to the time constraints.	To assure the effectiveness of the M/P, the revised M/P should be a binding document. However, the approval procedure isn't established yet.
	Organization	The PPCA, DPWT, and MPWT are implementing several projects independently within each responsible	IUTMP will be established in PPCA to plan and coordinate with relevant ministries. In future, the establishment

		Assumptions and development policy for formulating PPUTMP	Assumptions and development policy for revising PPUTMP (Draft)
		area.	of a Transport Planning Department within PPCA and collaboration with Kandal Province will be considered.
	Financial Source	Some projects are implemented with national budget, grant aid, etc. Large-scale projects such as urban railways have not been realized due to lack of funds.	To ensure linkage with the long-term budget plan, IUTMP will coordinated with MEF and MPWT during the process of revising and approving the M/P.

Source: JST

9.3 Recommendation

JST recommends:

- To implement the proposed priority projects (bus priority lanes, sidewalk improvement, parking management) timely and in an integrated manner;
- To do so, to enhance a coordination mechanism among stakeholders through the establishment of an urban transport platform in PPCA;
- To secure the budget for proposed priority projects, the revision and approval of PPUTMP fully utilising the study outputs;
- To maintain valuable urban transport database developed under this Project and utilise it to realise evidence-based priority projects and support the stakeholder consultation process.

Final Report
Appendix

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Appendix 1 Transport Surveys

1.1 Outline of Transport Surveys

A total of ten (10) transport surveys were carried out as follows in order to obtain various data being used for updating traffic data collected under PPUTMP in 2014, to understand the updated traffic situation, to develop transport models, and quantitative analysis for revision of PPUTMP by PPCA.

Table 1.1.1 List of Transport Surveys

	Survey contents	Objectives and Contents	Quantity
1	Person Trip Survey (PTS)	Home-visit interview surveys were conducted to understand resident's daily activity and travel records, personal attributes such as income and vehicle ownership, and the impact of the COVID-19 pandemic, in order to create a passenger Origin-Destination (OD) matrix.	Around 1,000 households
	Commuter Survey (CS)	Similar to Person Trip survey, but the survey form is more simplified by removing questions regarding daily activities.	Around 4,000 households
2	Cordon Line Survey (CLS)	OD interviews and vehicle count surveys were conducted to capture the OD traffic volume, cargo type and volume of passengers and cargo from outside the Survey area.	11 points on roads, 1 airport and 3 ferry terminals
3	Screen Line Survey (SLS)	To understand the amount of traffic flowing into the city centre and to verify the reproducibility of the traffic model in its current state, count surveys were conducted on screen lines.	12 points on roads (3 points covered by ITS)
4	Passenger Interview Survey (PIS)[1]	For each mode (passenger car, RHS, city/commuter bus[2], motorcycles), interviews were conducted at locations where users of each mode gathered in order to understand the characteristics of users, their awareness of traffic issues, and the possibility of shifting to a new mode.	Approximately 2,000 samples in total
5	Roadside Traffic Survey (RTS)	Count surveys were conducted to understand the traffic volume in the city and to verify the reproducibility of the traffic model.	17 points
6	Intersection Traffic Survey (ITS)	Traffic count surveys were conducted at major intersections to study intersection improvements and to verify the effectiveness of existing signals and flyovers.	13 points
7	Travel Speed Survey (TSS)[3]	Conduct speed surveys using GPS loggers to observe travel speed by mode and corridor. Also, the survey result will be used to identify the operation area of RHS.	13 passenger car routes 50 RHS vehicles 50 commuter buses
8	Parking Condition Survey (PCS)	Conduct interviews and count surveys at facilities and on streets to observe parking capacity, usage, and impact on roadways and sidewalks.	Facilities: 17 locations & On-street
9	RHS Driver Interview Survey	An interview survey was conducted with drivers to understand the actual status of RHS services, including vehicle kilometres travelled per vehicle (actual and empty), fare revenue, and number of trips.	Around 400 samples
10	Truck Interview Survey (TIS)	Conduct interviews with companies and drivers, and count surveys at PPSEZ and logistics hubs to estimate the percentage of cargo items and intra-regional cargo OD at major cargo hubs.	15 locations

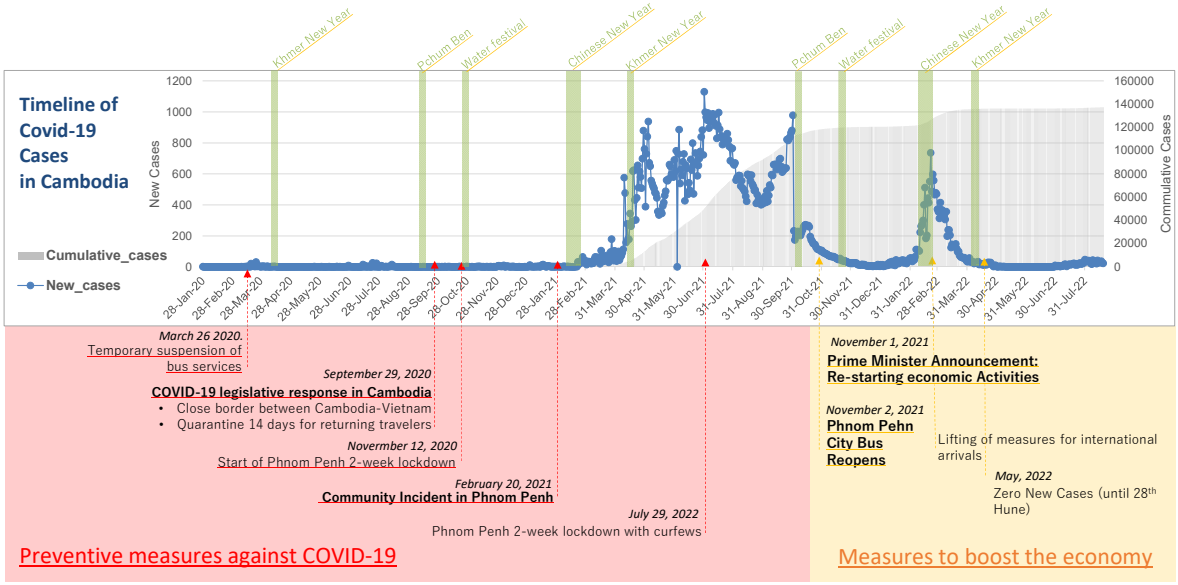
Source: JST

[1] The PT (Person Trip) survey is supplemented because it is difficult to obtain a sufficient sample of passenger cars, public and commuter buses, which have few users.
[2] Commuter buses: Buses operated by companies located mainly in the SEZ for commuting of their employees.
[3] GPS log data of City Bus was obtained through PiBO.

The transport surveys listed in Table 1.1.1 are generally the same as the transport survey conducted during PPUTMP in 2014. However, in order to grasp the situation of new transport modes, which are City Bus service and RHS tuk-tuk, they are additionally covered under the present transport surveys.

1.2 Effect of COVID-19 on Transport Behaviour in Phnom Penh

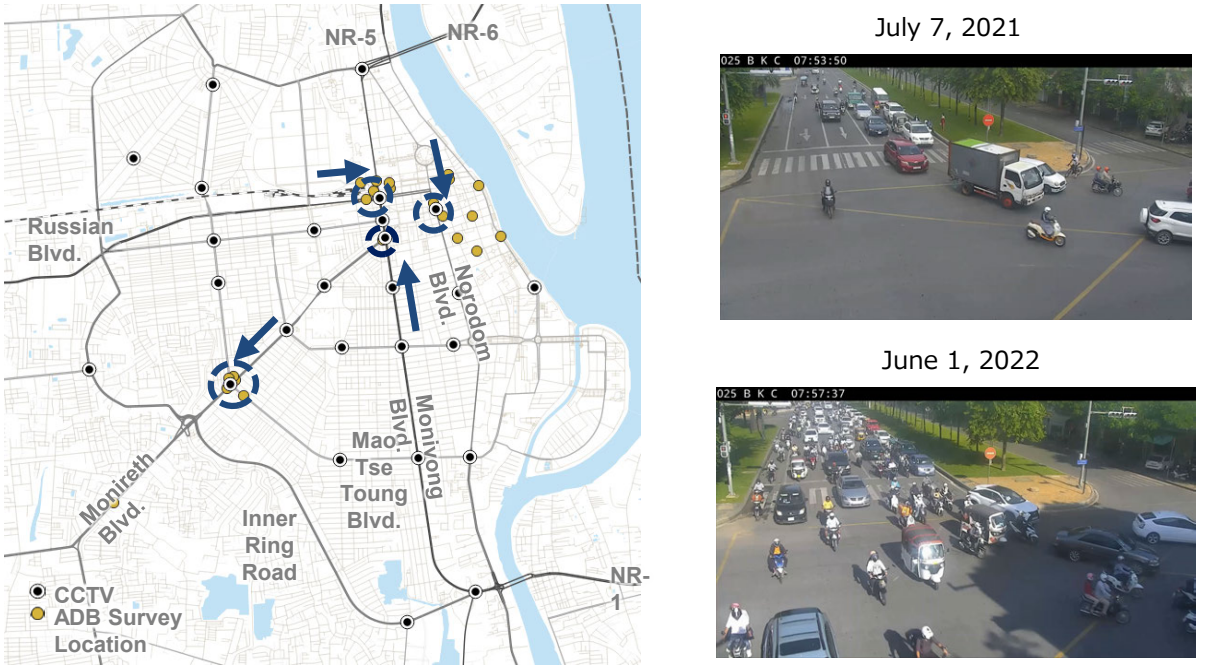
In Cambodia, the number of cases of COVID-19 was limited by February 2021 as shown in Figure 1.2.3. However, it has increased from February 2021 until October 2021. Later in November 2021, the Prime Minister announced the re-activation of the economy, and City Bus is also re-started operation immediately after the announcement. The traffic behaviour was highly affected by such daily news of cases and social restrictions such as curfew.



Source: JST based on the information from WHO and news articles

Figure 1.2.1 New Cases of COVID-19 and Counter Measures in Cambodia

In order to judge the appropriate timing to start the transport surveys, traffic volume has been monitored using CCTV camera data as shown in Figure 1.2.2. The results are compared with the traffic volume survey results in 2019 which was conducted by the ADB survey team. Traffic volume has been counted once every other week since July 2021 for one hour each in the morning, noon, and evening, by vehicle type. Figure 1.2.3 shows the recovery rate of traffic volume compared to that in 2019 based on the total PCU (Passenger Car Unit) volume at 4 locations. The recovery index reached 90% in January 2022. Considering the index, transport surveys were initiated consulting with PPCA and Khans.



Source: JST

Figure 1.2.2 Location of Traffic Monitoring by CCTV and the Captured Traffic Condition

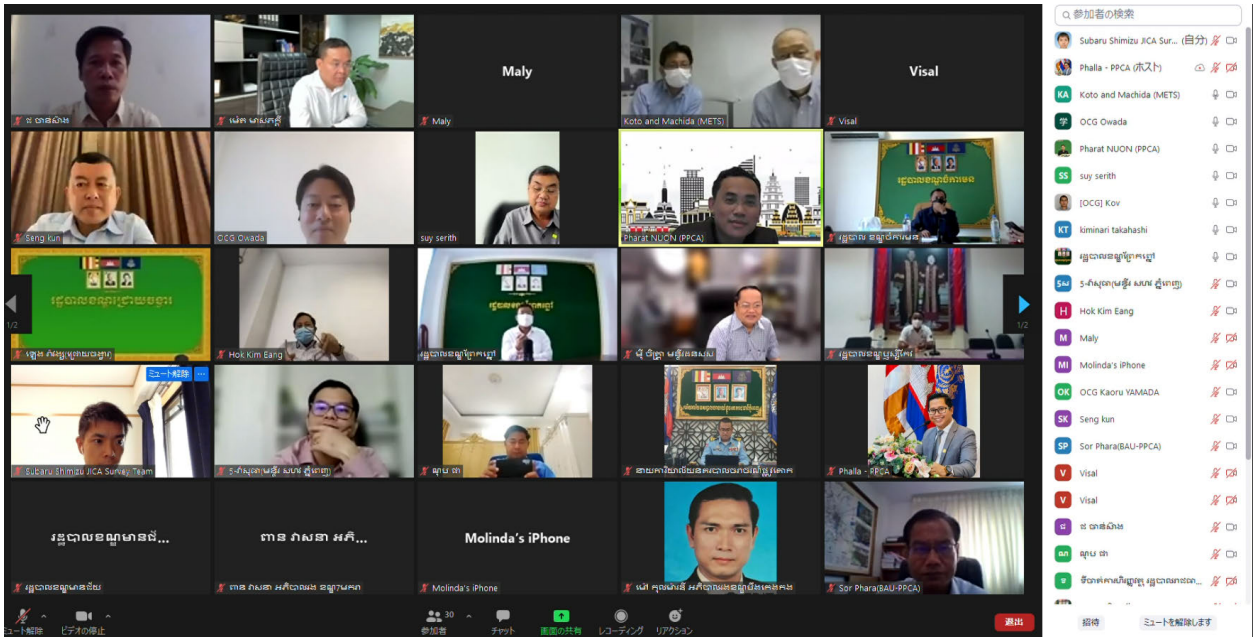
Source: JST based on the information from WHO and news articles

Figure 1.2.3 Traffic Volume Recovery Index at 4 Locations and Schedule of Surveys

1.2.1 Discussions with PPCA

In consideration of the effect of COVID-19, a series of meetings with counterpart officials from PPCA has been made via videoconferences to share the overall progress and to discuss the way forward with regards to the transport surveys and data/information collection process. On September 10th, 2021, a meeting with

related stakeholders, particularly traffic police, all 14 Khan Authorities, and DPWT under the chairmanship of PPCA Deputy Governors was held.



Source: JST

Figure 1.2.4 Stakeholder Meetings for Transport Surveys

The major conclusions are summarised as follows.

(1) Modification of Transport Survey Methodology

Out of the 10 items of transport surveys being planned, there were comments only on the methodology of Person Trip Survey, which can be summarised in 2 points:

- Request to minimize the number of questions and physical contact (i.e. number of home visiting time) to prevent COVID-19 infection;
- Suggestion on utilizing the latest result of Population Census.

In response to the above comments, the JICA Survey Team has proposed to modify from the initial plan of 5,000 households Person Trip Survey to a combination of 1,000 households Person Trip Survey and 4,000 household Commuter Survey. This proposed plan has been shared with PPCA and approved.

(2) Criteria to Start, Suspend Survey under COVID-19 Pandemic

Since the transport survey was conducted under the COVID-19 pandemic, the criteria for starting/ suspending the transport surveys was prepared using behavioural restrictions and the traffic volume recovery rate as indicators. The criteria was shared with PPCA and was officially agreed.

Table 1.2.1 Criteria to Start, Suspend Survey under COVID-19 Pandemic

	Survey Items	Restrictions	Traffic Volume Recovery
A	RHS driver interview & Passenger interview survey	**<u>Common Criteria:</u>** • Permission of Local Authority • One week after Orange / Yellow zone released	70% Compared to 2019
B	Mini PT Survey (100 HHs)		

	Survey Items	Restrictions	Traffic Volume Recovery
C	Other surveys	• Common Criteria + One week after offices open	90% Compared to 2019
D	PT Survey (900 HHs) Commuter Survey (4,000 HHs)	• Common Criteria + One week after schools open	

HH: Household
PT Survey: Person Trip Survey
Source: JST

(3) Transport Surveys under COVID-19 Pandemic

The following measures were taken to conduct the transport surveys safely and get the meaningful survey results under the COVID-19 pandemic.

Infection Control for Transport Surveys

- Communication with Local Authority before starting survey;
- Infection control measures during survey (guideline for surveyors, surveyor education, alcohol-based sanitizer, mask)
- Conduct remote surveys (Telegram, Zoom) when possible to reduce physical contacts.

Estimation of the Impact on Travel Behaviour

- Interview changes in trip frequency and trip mode before and after the COVID-19 pandemic to understand the impact on the transport behaviour of residents.
- Analyse mobile GPS data before and after the COVID-19 pandemic and estimate the changes in trip frequency and trip length, which is useful for interpreting and correcting transport surveys results.

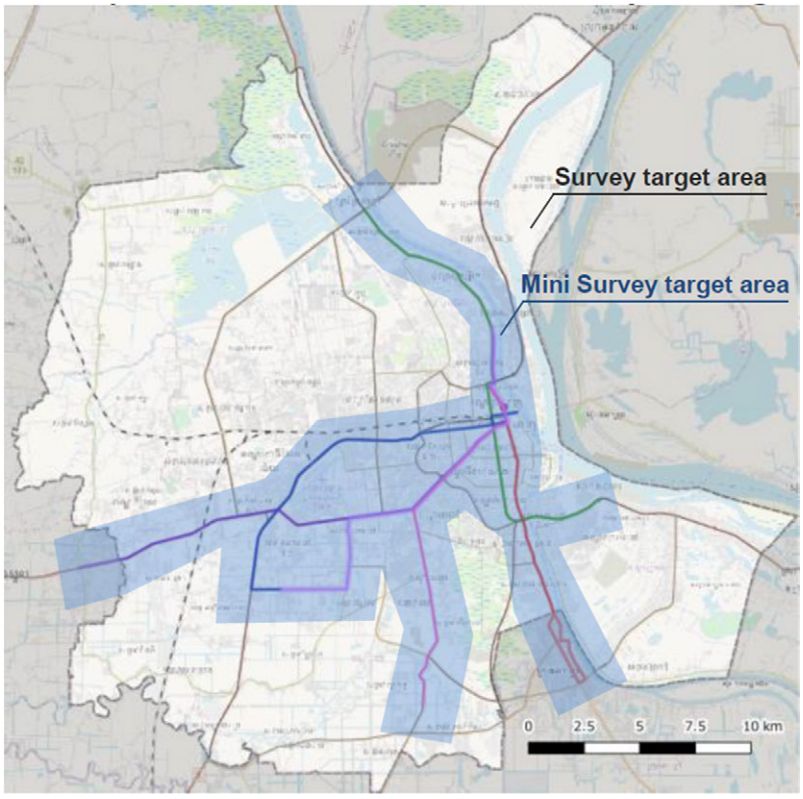
1.3 Description/ Result of Transport Surveys

1.3.1 Person Trip Survey/Commuter Survey

(1) Outline

The person Trip (PT) Survey was carried out in the JICA2001MP study for the first time in 2000 and the second time in 2012. The number of samples was extracted from the General Population Census data of 1998 and 2008, based on the number of households and population. In the Survey, the number of samples was also designed based on the General Population Census in 2019 by taking into consideration the number of households.

Due to the difficulty in conducting the Survey under the COVID-19 pandemic, the Person Trip Survey was separated into two stages. Mini Person Trip Survey (hereinafter referred to as "the Mini Survey") was conducted with a limited number of samples along the planned bus priority lanes in the first stage. After confirming the pandemic situation had settled down, the full-scale Survey was conducted following the Mini Survey (See Figure 1.3.1).



Source: JST

Figure 1.3.1 Survey Target Area of Mini Survey and Full Scale Survey

The common objectives of the Person Trip Survey and Commuter Survey are:

- To understand the trip characteristics (e.g. origin and destination, mode, travel time, cost, etc.) as well as to collect the individual and household socio-economic attributes of the residents in the survey area;
- To obtain the trip rate of the traffic analysis zones in the Survey area; and
- To collect necessary information to estimate OD table of the base year.

The survey questionnaire of Person Trip Survey and Commuter Survey were prepared as shown in Table 1.3.1.

Table 1.3.1 Questionnaire Items in Person Trip Survey and Commuter Survey

Type of Survey	Categories	Questionnaire Items
Person Trip Survey	Form 1: Household Information	• Address of residence • Number of household members • Household monthly income • Vehicles ownership • Member goes to grocery store, travel mode and frequency in a week • Current situation compared to before Covid-19 pandemic
	Form 2: Household Member Attributes (aged 5 years and above)	• Relation to head of household • Age and gender • Individual monthly income • Occupation and sector • Work/School address • Frequency, travel mode, departure and arrival time of work/school trip in a week • Current situation compared to before Covid-19 pandemic • Willingness to walk to bus stop
	Form 3: Daily Trip Activities (aged 5 years and above)	• Address of OD • Departure and arrival time • Trip purpose • Travel mode
Commuter Survey	Form 1: Household Information	• Address of residence • Number of household members • Household monthly income • Vehicles ownership • Member goes to grocery store, travel mode and frequency in a week • Current situation compared to before Covid-19 pandemic
	Form 2: Household Member Attributes (aged 5 years and above)	• Relation to head of household • Age and gender • Individual monthly income • Occupation and sector • Work/School address
	Form 3: Commuting Trip Information	• Address of OD • Frequency, travel mode, departure and arrival time of work/school trip in a week • Current situation compared to before Covid-19 pandemic

Source: JST

(2) Survey Coverage

The Survey covers the entire administrative area of Phnom Penh Capital City, which include 14 districts with 145 TAZ (See Figure 1.3.2). While an additional 18 TAZ systems were used to represent zones outside Phnom Penh and another three TAZ represent the neighbouring countries of Cambodia.

(3) Survey Method

The effective sampling ratio is set at 1 percent of the households in Phnom Penh based on the General Population Census data in 2019. The number of target households was estimated at around 5,000 households with the average household size of 5.3.

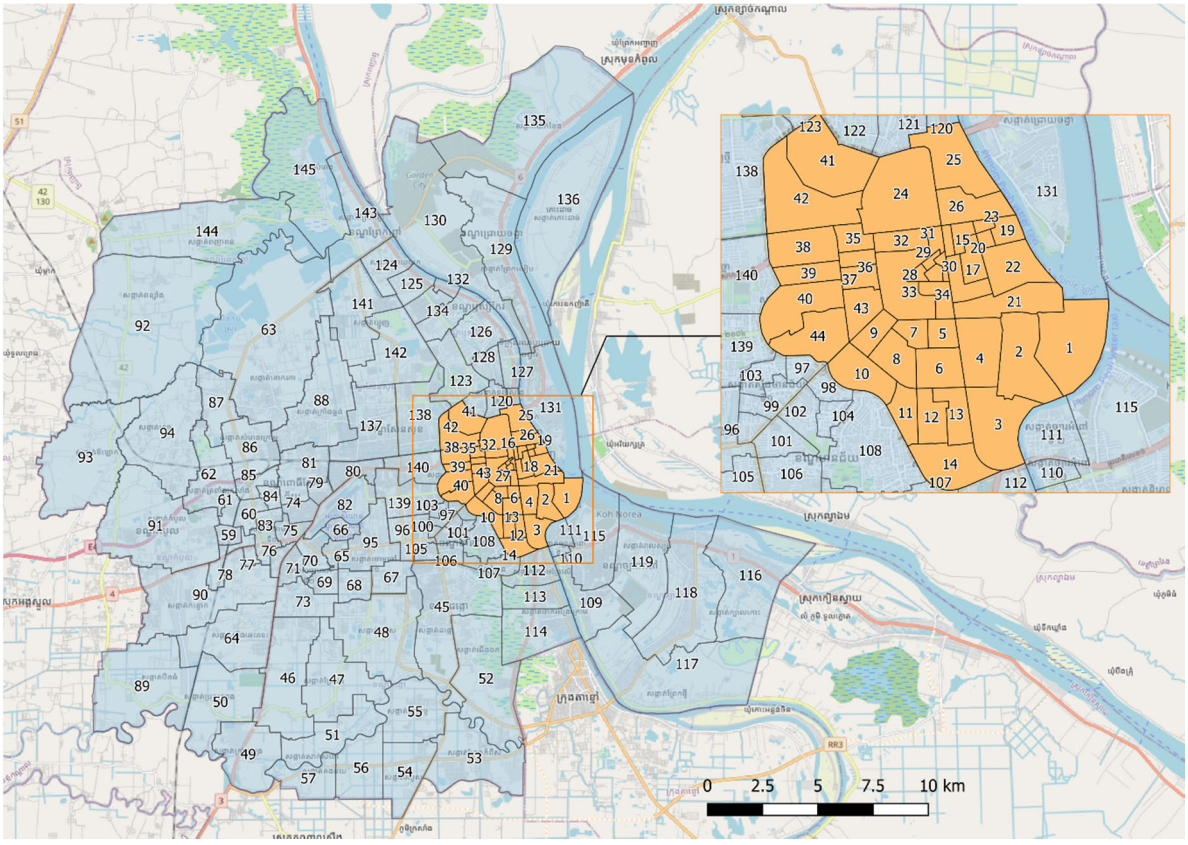
Household members aged 5 years old and above were interviewed during the survey and household members aged under 5 years old were excluded from the survey. The sample size for the Person Trip Survey and Commuter Survey for Mini-survey and Full-scale survey is showed in Table 1.3.2.

Table 1.3.2 Survey type and Sample Size

Survey Type	Person Trip Survey		Commuter Survey
	Mini-Survey	Full-scale Survey	
Number of Samples	100 households (along bus priority lanes)	900 households	4,000 households
Number of Visits to each Household	2 times	2 times	1 time

Source: JST

In the Person Trip Survey and Commuter Survey, the distribution of the questionnaires to target 5,000 households (1,000 samples for person trip survey and 4,000 for commuter survey) was conducted every day in a week. However, the trip information which have been made on weekdays (Monday-Friday) were interviewed.



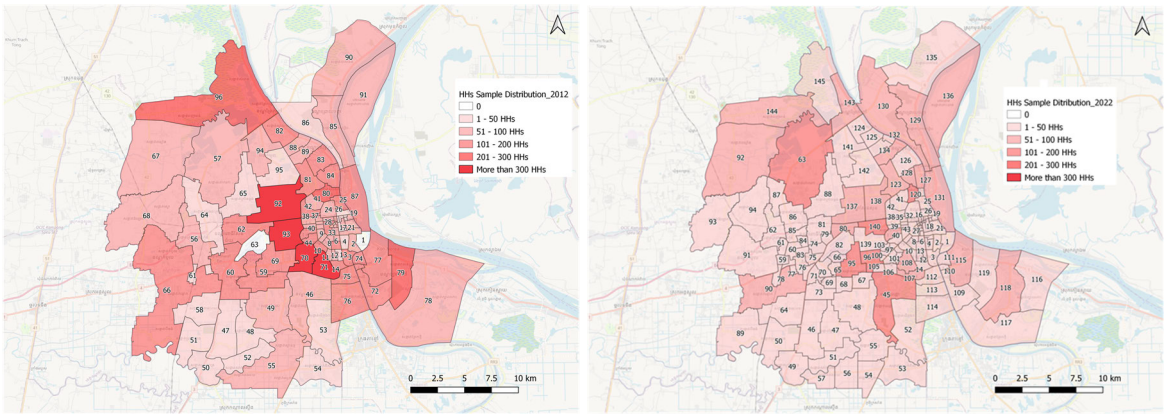
Source: JST

Figure 1.3.2 TAZ Systems for Person Trip/Commuter Survey

(4) Survey Results

1) Number of Interviews and Household Size

Figure 1.3.3 shows the household samples collected in each TAZ in 2012 and 2022. In order to minimize infection risks of COVID-19, the Person Trip Survey for 1,000 households and the Commuter Survey for 4,000 households were conducted in 2022, whilst only the Person Trip Survey was conducted in 2012. The detailed sample size by TAZ in 2012 and 2022 are illustrated in Table 1.3.3 and Table 1.3.4 respectively.



Source: JST

Figure 1.3.3 Sample Distribution in each TAZ System in 2012 and 2022

Table 1.3.3 Number of Interviewed Households in 2012

Zone No.	Sangkat	Number of Households in Census 2008	No. of Sample Households (PT)	No. of Sample Households (CS)
1	Tonle Basak	0	0	0
2	Tonle Basak	2,533	80	0
3	Tonle Basak	3,719	117	0
4	Boeng Keng Kang Muoy	2,363	46	0
5	Boeng Keng Kang Pir	2,161	68	0
6	Boeng Keng Kang Bei	4,219	132	0
7	Oulampik	1,709	54	0
8	Tuol Svay Prey Ti Muoy	2,479	79	0
9	Tuol Svay Prey Ti Pir	1,933	61	0
10	TumnobTuek	3,422	108	0
11	Tuol Tumpung Ti Pir	2,024	64	0
12	Tuol Tumpung Ti Muoy	2,276	72	0
13	Boeng Trabaek	1,601	50	0
14	Phsar Daeum Thkov	4,227	136	0
15	Phsar Thmei Ti Muoy	1,269	40	0
16	Phsar Thmei Ti Pir	1,367	43	0
17	Phsar Thmei Ti Bei	2,005	63	0
18	Boeng Reang	1,295	41	0

Zone No.	Sangkat	Number of Households in Census 2008	No. of Sample Households (PT)	No. of Sample Households (CS)
19	Phsar Kandal Ti Mouy	1,886	59	0
20	Phsar Kandal Ti Pir	1,489	47	0
21	Chakto Mukh	1,924	61	0
22	Chey Chummeah	2,180	68	0
23	Phsar Chas	1,469	46	0
24	Srah Chak	4,775	77	0
25	Srah Chak	3,268	175	0
26	Voat Phnum	1,274	41	0
27	Ou Ruessei Ti Muoy	1,645	53	0
28	Ou Ruessei Ti Pir	1,917	60	0
29	Ou Ruessei Ti Bei	1,601	50	0
30	Ou Ruessei Ti Buon	1,775	56	0
31	Monourom	2,287	72	0
32	Mittakpheap	2,152	67	0
33	Veal Vong	5,267	165	0
34	Boeng Prolit	1,869	59	0
35	Phsar Depou Ti Muoy	1,959	61	0
36	Phsar Depou Ti Pir	2,126	67	0
37	Phsar Depou Ti Bei	1,666	52	0
38	Tuek L'ak Ti Muoy	2,815	88	0
39	Tuek L'ak Ti Pir	2,428	76	0
40	Tuek L'ak Ti Bei	4,761	149	0
41	Boeng Kak Ti Muoy	2,762	87	0
42	Boeng Kak Ti Pir	5,468	171	0
43	Phsar Daeum Kor	2,757	86	0
44	Boeng Salang	6,354	199	0
45	Phnom Penh Port	0	0	0
46	Dangkao	2,977	93	0
47	Pong Tuek	1,468	46	0
48	Preyveaeng	1,119	36	0
49	Prey Sa	1,845	58	0
50	Krang Pongro	592	19	0
51	Prateaah Lang	1,030	32	0
52	Sak Sampov	538	27	0
53	Cheung Aek	1,508	47	0
54	Prek Kampeus	1,618	30	0
55	Kong Noy	334	87	0
	Rolous	662		0
	Spean Thmor	628		0
	Tien	479		0
56	Trapeang Krasang	2,520	79	0
57	Kouk Roka	2,440	77	0

Zone No.	Sangkat	Number of Households in Census 2008	No. of Sample Households (PT)	No. of Sample Households (CS)
58	Phleung Chheh Roteh	1,120	35	0
59	Chaom Chau	6,246	195	0
60	Chaom Chau	4,999	158	0
61	Chaom Chau	1,274	40	0
62	Kakab	6,278	197	0
63	Kakab	0	0	0
64	Samraong Kraom	1,182	37	0
65	Krang Thnong	973	31	0
66	Boeung Thom	1,508	115	0
	Kambol	1,612		0
	Kantork	2,458		0
67	Ovleok	723	58	0
68	Pon sang	1,880	57	0
	Snor	1,035		0
69	Stueng Mean Chey	2,481	110	0
70	Stueng Mean Chey	15,523	351	0
71	Boeng Tumpun	10,968	347	0
72	Preaek Pra	3,500	110	0
73	Chhbar Ampov Ti Muoy	1,739	108	0
74	Chhbar Ampov Ti Pir	5,090	160	0
75	Chak Angrae Leu	4,491	141	0
76	Chak Angrae Kraom	5,515	173	0
77	Nirouth	4,032	127	0
78	Kbal Koh	3,709	60	0
	Prek Thmei	3,427		0
79	Prek Eng	3,080	263	0
	Veal Sbov	1,878		0
80	Tuol Sangkae	5,971	215	0
81	Toul Sangkae (Camko City)	4,309	108	0
82	Svay Pak	3,402	107	0
83	Kilomaetr Lekh Prammuoy	3,327	104	0
84	Ruessei Kaev	5,007	157	0
85	Preaek Lieb	2,706	85	0
86	Preaek Ta Sek	1,159	36	0
87	Chrouy Changvar	4,022	126	0
88	Chrang Chamreh Ti Muoy	1,801	57	0
89	Chrang Chamreh Ti Pir	2,671	84	0
90	Bakkeng	1,837	58	0
91	Kosh Dach	2,728	86	0
92	Phnom Penh Thmei	7,831	328	0
93	Tuek Thla	11,966	375	0
94	Khmuonh	3,862	93	0

Zone No.	Sangkat	Number of Households in Census 2008	No. of Sample Households (PT)	No. of Sample Households (CS)
95	Khmuonh	510	45	0
96	Pongea Pon	1,289	225	0
	Prek Phnov	2,532		0
	Samrong	1,473		0
Total		**295,358**	**9,239**	

Source: JST

Table 1.3.4 List of Interviewed Households in 2022

Zone No.	Sangkat	Number of Households in Census 2019	No. of Sample Households (PT)	No. of Sample Households (CS)
1	Tonle Basak	997	5	5
2	Tonle Basak	3,033	22	14
3	Tonle Basak	2,892	16	11
4	Boeng Keng Kang Muoy	1,325	2	21
5	Boeng Keng Kang Pir	1,939	4	14
6	Boeng Keng Kang Bei	3,285	6	35
7	Oulampik	1,256	3	12
8	Tuol Svay Prey Ti Muoy	1,950	4	18
9	Tuol Svay Prey Ti Pir	1,411	4	17
10	Tumnob Tuek	1,509	3	14
11	Tuol Tumpung Ti Pir	878	5	5
12	Tuol Tumpung Ti Muoy	2,168	10	13
13	Boeng Trabaek	1,767	9	8
14	Phsar Daeum Thkov	3,651	17	22
15	Phsar Thmei Ti Muoy	1,708	4	16
16	Phsar Thmei Ti Pir	1,746	5	13
17	Phsar Thmei Ti Bei	2,770	5	23
18	Boeng Reang	1,841	4	7
19	Phsar Kandal Ti Muoy	2,901	6	31
20	Phsar Kandal Ti Pir	2,573	5	9
21	Chakto Mukh	2,303	5	17
22	Chey Chummeah	2,033	5	19
23	Phsar Chas	2,362	7	25
24	Srah Chak	4,253	8	21
25	Srah Chak	4,363	8	42
26	Voat Phnum	2,143	4	17
27	Ou Ruessei Ti Muoy	1,427	2	11
28	Ou Ruessei Ti Pir	1,761	4	11
29	Ou Ruessei Ti Bei	1,296	2	13
30	Ou Ruessei Ti Buon	1,190	2	10
31	Monourom	2,097	7	22
32	Mittakpheap	1,948	6	14

Zone No.	Sangkat	Number of Households in Census 2019	No. of Sample Households (PT)	No. of Sample Households (CS)
33	Veal Vong	4,522	6	27
34	Boeng Prolit	1,342	2	12
35	Phsar Depou Ti Bei	1,482	3	16
36	Phsar Depou Ti Pir	1,993	5	15
37	Phsar Depou Ti Muoy	1,729	6	15
38	Tuek L'ak Ti Muoy	2,021	6	18
39	Tuek L'ak Ti Pir	2,323	5	17
40	Tuek L'ak Ti Bei	5,639	9	50
41	Boeng Kak Ti Muoy	2,833	7	21
42	Boeng Kak Ti Pir	4,874	9	40
43	Phsar Daeum Kor	2,516	8	27
44	Boeng Salang	5,698	11	36
45	Dangkao	18153	17	168
46	Pong Tuek	3,245	9	26
47	Prey Veaeng	1,700	2	17
48	Prey Sa	3,766	2	36
49	Krang Pongro	956	2	7
50	Prateah Lang	1,484	2	14
51	Sak Sampov	763	3	7
52	Cheung Aek	2,987	4	24
53	Preaek Kampues	2,115	2	16
54	Roluos	885	1	0
55	Spean Thma	798	14	23
56	Tien	695	1	0
57	Kong Noy	472	1	1
58	Chaom Chau Ti 3	1,030	1	7
59	Trapeang Krasang	1,160	1	13
60	Trapeang Krasang	545	1	10
61	Trapeang Krasang	876	2	8
62	Trapeang Krasang	2,130	1	8
63	Kouk Roka	13,414	24	107
64	Phleung Chheh Roteh	1,475	3	14
65	Chaom Chau Ti 2	2,253	3	12
66	Chaom Chau Ti 2	1,894	5	13
67	Chaom Chau Ti 1	2,001	5	18
68	Chaom Chau Ti 1	502	3	10
69	Chaom Chau Ti 2	669	1	8
70	Chaom Chau Ti 2	1,212	4	9
71	Chaom Chau Ti 2	1,628	4	10
72	Chaom Chau Ti 3	1122	3	8
73	Chaom Chau Ti 2	1,868	2	9
74	Chaom Chau Ti 3	4,482	11	29

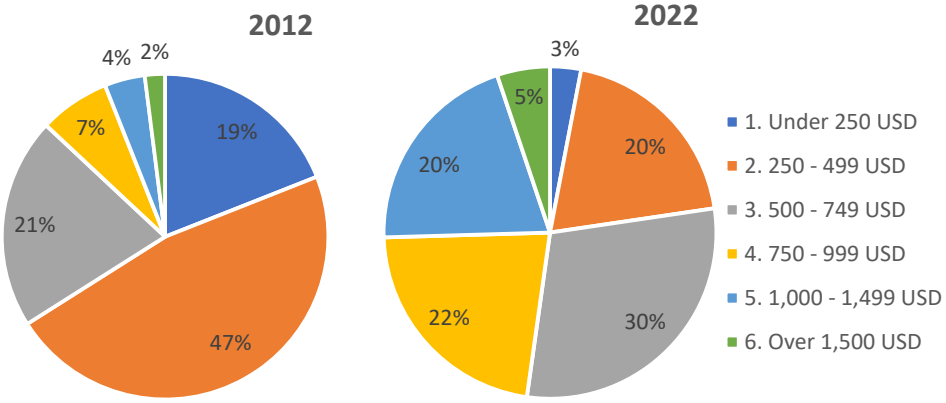
Zone No.	Sangkat	Number of Households in Census 2019	No. of Sample Households (PT)	No. of Sample Households (CS)
75	Chaom Chau Ti 3	3,682	8	30
76	Chaom Chau Ti 3	6,369	13	36
77	Chaom Chau Ti 3	448	4	9
78	Chaom Chau Ti 3	880	2	7
79	Kakab Ti 2	1,032	2	10
80	Kakab Ti 1	7,106	15	63
81	Kakab Ti 2	4,058	6	32
82	Kakab Ti 1	1,423	3	20
83	Chaom Chau Ti 3	643	5	17
84	Samraong Kraom	493	2	6
85	Samraong Kraom	131	2	6
86	Samraong Kraom	1,059	1	5
87	Samraong Kraom	649	1	5
88	Krang Thnoang	4,307	8	35
89	Boeng Thum	2,183	5	22
90	Kantaok	7,193	10	67
91	Kamboul	3,342	6	34
92	Ponsang	9,217	15	74
93	Ovlaok	1,074	4	15
94	Snaor	1,406	6	17
95	Chaom Chau Ti 1	14,123	24	103
96	Stueng Mean cheyTI 3	14,293	12	135
97	Stueng Mean chey TI 1	1,320	3	11
98	Stueng Mean cheyTI 2	1,018	2	9
99	Stueng Mean chey TI 1	2,920	6	20
100	Stueng Mean chey TI 1	1,337	2	12
101	Stueng Mean cheyTI 2	1,032	3	8
102	Stueng Mean cheyTI 2	2,343	4	19
103	Stueng Mean chey TI 1	2052	5	19
104	Stueng Mean cheyTI 2	2,179	4	17
105	Stueng Mean cheyTI 3	1,150	4	6
106	Stueng Mean cheyTI 2	2,220	6	17
107	Boeng Tumpun Ti 2	6,912	18	40
108	Boeng Tumpun Ti 1	8,101	24	54
109	Preaek Pra	5,046	8	40
110	Chhbar Ampov Ti Muoy	1,694	3	10
111	Chhbar Ampov Ti Pir	4,535	9	33
112	Chak Angrae Leu	4,379	15	31
113	Chak Angrae Kraom	3,665	9	29
114	Chak Angrae Kraom	4,109	10	28
115	Nirouth	7,561	8	54
116	Kbal Kaoh	3,982	3	27

Zone No.	Sangkat	Number of Households in Census 2019	No. of Sample Households (PT)	No. of Sample Households (CS)
117	Preaek Thmei	5,232	10	39
118	Preaek Aeng	3,959	4	56
119	Veal Sbov	3,235	6	24
120	Tuol Sangkae 1	2,546	5	18
121	Tuol Sangkae 1	13,597	30	97
122	Tuol Sangkae 1	4,278	8	35
123	Tuol Sangkae 2	9,690	19	77
124	Svay Pak	2,668	4	15
125	Svay Pak	1,421	7	20
126	Kilomaetr Lekh Prammuoy	4,858	9	40
127	Ruessei Kaev	6,755	11	67
128	Ruessei Kaev	6,959	10	50
129	Preaek Lieb	8,560	7	78
130	Preaek Ta Sek	6,629	9	55
131	Chrouy Changvar	6,884	12	65
132	Chrang Chamreh Ti Muoy	1,857	5	22
133	Chrang Chamreh Ti Muoy	2,829	4	11
134	Chrang Chamreh Ti Pir	5,213	14	43
135	Bak Kaeng	3,890	7	32
136	Kaoh Dach	6,556	10	53
137	Kouk Khleang	10,069	21	72
138	Phnom Penh Thmei	5,775	9	46
139	Ou Baek K'am	5,391	10	40
140	Tuek Thla	11,944	26	100
141	Khmuonh	3,455	7	27
142	Khmuonh	1,199	0	9
143	Preaek Phnov	6,218	11	43
144	Ponhea Pon	7,503	14	53
145	Samraong	4,146	7	32
TOTAL		**498,010**	**1,006**	**4,007**

Source: JST

2) Household Income

Figure 1.3.4 shows the composition of household monthly income class in 2012 and 2022. More than 66% of households have a monthly income of less than USD 500 in 2012 and this number significantly dropped down to 23% in 2022. Meanwhile, only 28% of households in 2012 had a monthly income ranging from USD 500 – 1,000, and has dramatically rose to 52% in 2022. Additionally, the number of households with a monthly income over USD 1,000 also showed significant changes from 6% in 2012 to 25% in 2022.



Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

Figure 1.3.4 Comparison of Household Monthly Income between 2012 and 2022

3) Motorbike and Car Ownership

In 2012, around 80% of households whose income is less than USD 500 a month owned only a motorbike (and no car) while 40% of households with monthly income of USD 750-999 own both a motorbike and a car (see Table 1.3.5).

In 2022, approximately 81.28% of households whose income is less than USD 500 a month own only a motorbike (and no car) while 42.0% of households with monthly income of USD 750-999 own both a motorbike and a car (see Table 1.3.6).

Table 1.3.5 Household Income Level and Vehicle Ownership in 2012

Household Monthly Income	No Motorbike and No Car	Motorbike Only and No Car	Motorbike and Car	TOTAL
1. Under 250 USD	15.8%	77.5%	6.8%	100%
2. 250 - 499 USD	7.7%	79.8%	12.4%	100%
3. 500 - 749 USD	4.6%	67.3%	28.1%	100%
4. 750 - 999 USD	2.5%	58.5%	39.0%	100%
5. 1,000 - 1,499 USD	1.6%	46.2%	52.3%	100%
6. Over 1,500 USD	3.1%	32.3%	64.6%	100%

Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

Table 1.3.6 Household Income Level and Vehicle Ownership in 2022

Household Monthly Income	No Motorbike and No Car	Motorbike Only and No Car	Motorbike and Car	TOTAL
1. Under 250 USD	13.7%	81.3%	5.0%	100%
2. 250 - 499 USD	2.8%	79.9%	17.3%	100%

Household Monthly Income	No Motorbike and No Car	Motorbike Only and No Car	Motorbike and Car	TOTAL
3. 500 - 749 USD	0.8%	69.3%	29.9%	100%
4. 750 - 999 USD	0.3%	57.7%	42.0%	100%
5. 1,000 - 1,499 USD	0.1%	47.1%	52.8%	100%
6. 1,500 - 1,999 USD	0.0%	37.4%	62.6%	100%
7. Over 2,000 USD	1.2%	28.2%	70.5%	100%

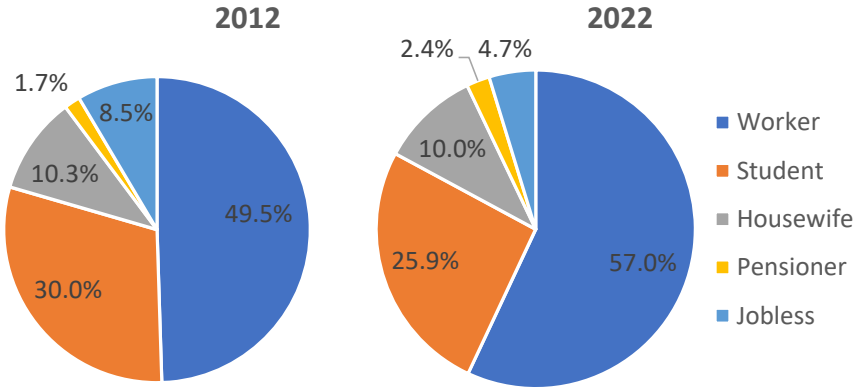
Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

4) Occupation and Sector

Occupation

There are 16 occupation categories in the survey. These categories were integrated into 5 categories, namely: Worker, Student, Housewife, Pensioner, and Jobless. In 2012, the occupation with the highest number of household members is "Worker," with a share of about 50%. In 2022, the occupation with the highest number of household members is also “Worker," with a share of 57% (Figure 1.3.5).



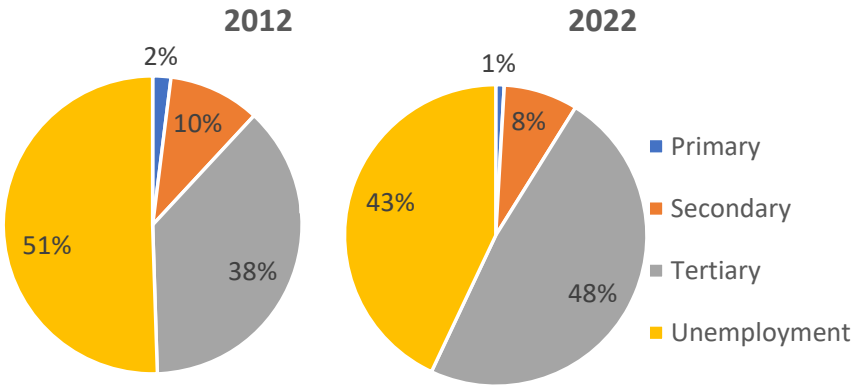
Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

Figure 1.3.5 Comparison of Occupation in 2012 and 2022

Sector

Figure 1.3.6 shows that in 2012, the highest sector is “Unemployment” with a share of 51% followed by “Tertiary” (38%), “Secondary” (10%) and “Primary” (2%). In 2022, the highest sector is “Tertiary” with a share of 48% followed by “Unemployment” (43%), “Secondary” (8%) and “Primary” (1%).



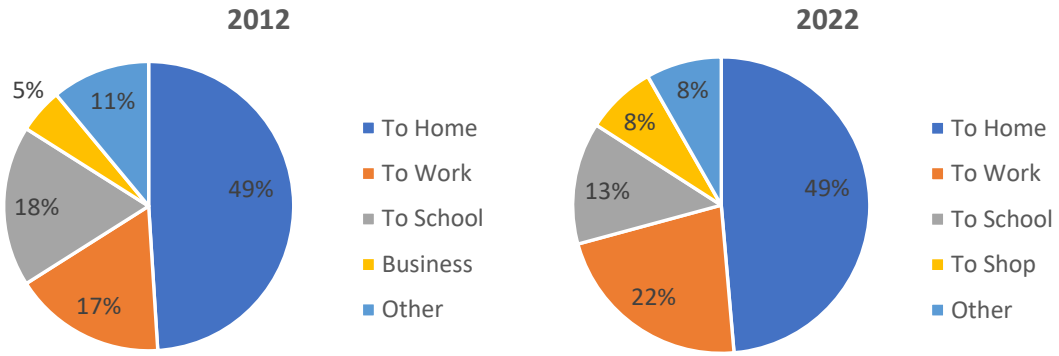
Note:
1. Primary Sector: Agriculture, Forestry and Fishing
2. Secondary Sector: Mining and Quarrying, Manufacturing, Construction
3. Tertiary Sector: Wholesale and Retail Trade, Financial, Insurance and Real Estate, Transport & Communication, Electricity Gas and Water Supply, Service, Official Service
4. Unemployment: Jobless, Pensioner, Housewife, Student.
5. The results of PT survey in 2012 included the expansion factor.
6. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

Figure 1.3.6 Sector Type in 2012 and 2022

5) Trip Purpose

Figure 1.3.7 illustrates the trip purpose between 2012 and 2022. In 2012, most household members (49% of samples) make “To Home” trips, followed by trips “To Work” (17%), “To School” (18%), “Business” (5%), and Others (11%). In 2022, most household members (49% of samples) make “To Home” trips, followed by trips “To Work” (22%), “To School” (13%), “To Shop” (8%), and Others (8%). It should be noted that “Business” trip in 2012 and “To Shop” trip in 2022 are in different trip purposes.



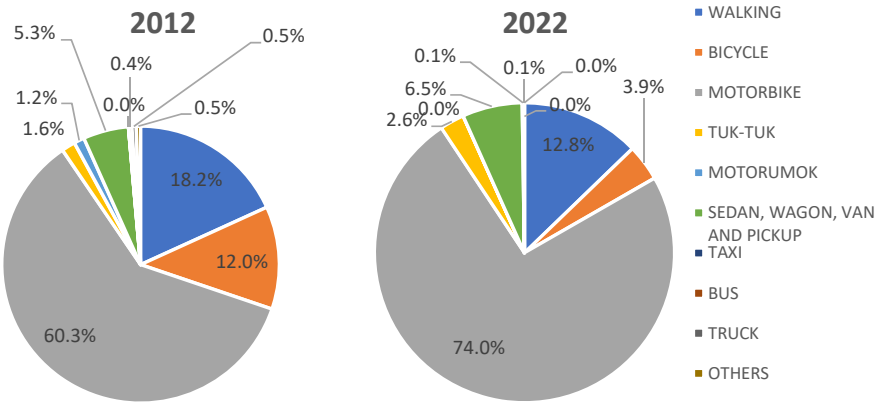
Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

Figure 1.3.7 Trip Purpose in 2012 and 2022

6) Travel Mode

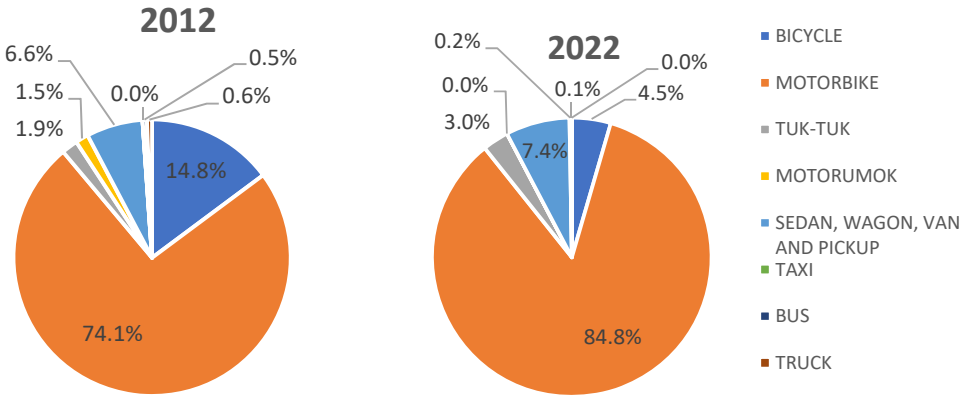
Figure 1.3.8 shows that in 2012, trips by "Motorbike" has the highest share of 60.3% followed by "Walking" (18.2%), "Bicycle" (12%), "Sedan, Wagon, Van" (5.3%) and "Tuk-Tuk" (1.6%). While in 2022, trip by "Motorbike" still has the highest share and increased to 74% followed by "Walking" (12.8%), "Sedan, Wagon, Van" (6.5%), "Bicycle" (3.9%) and "Tuk-Tuk" (2.6%).



Note: The results are calculated by using samples based dataset from person trip survey.
Source: JST

Figure 1.3.8 Travel Mode in 2012 and 2022

Figure 1.3.9 shows the trip mode excluding walking and others in 2012 and 2022. Among vehicular trips, the "Motorbike" has a modal share of 74.0% while "Sedan" trip has a 6.6% share in 2012. In 2022, "Motorbike" has a modal share of 85.0% while "Sedan" trip has a 7.4% share. This corresponds to the households' vehicle ownership where the majority own motorbikes.



Note:
1. The results of PT survey in 2012 included the expansion factor.
2. The results of PT survey in 2022 were calculated based on sample based data.

Source: JST

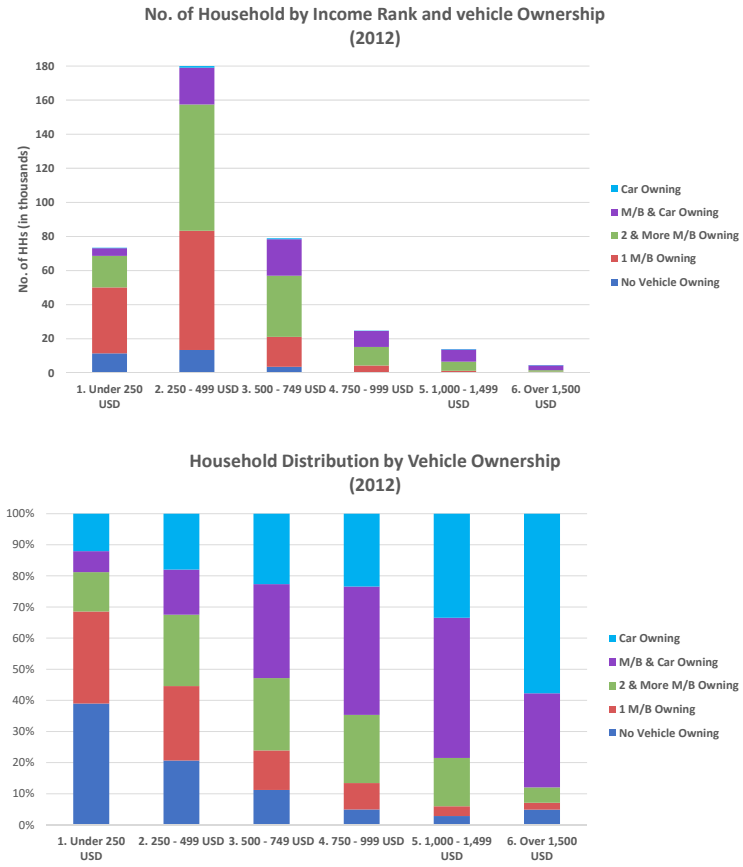
Figure 1.3.9 Travel Mode in 2012 and 2022 (Excluding Walking and Others)

(5) Existing Transport Characteristics

Generally, the objective of situation analysis of existing transport is to clarify the urban structure of a study area, its land use, current transport situation, and their effects and issues by analysing the results of transport surveys, collected information and statistics. However, in this part, the existing situation are analysed as an

important step to specify the development direction of demand forecasting models.

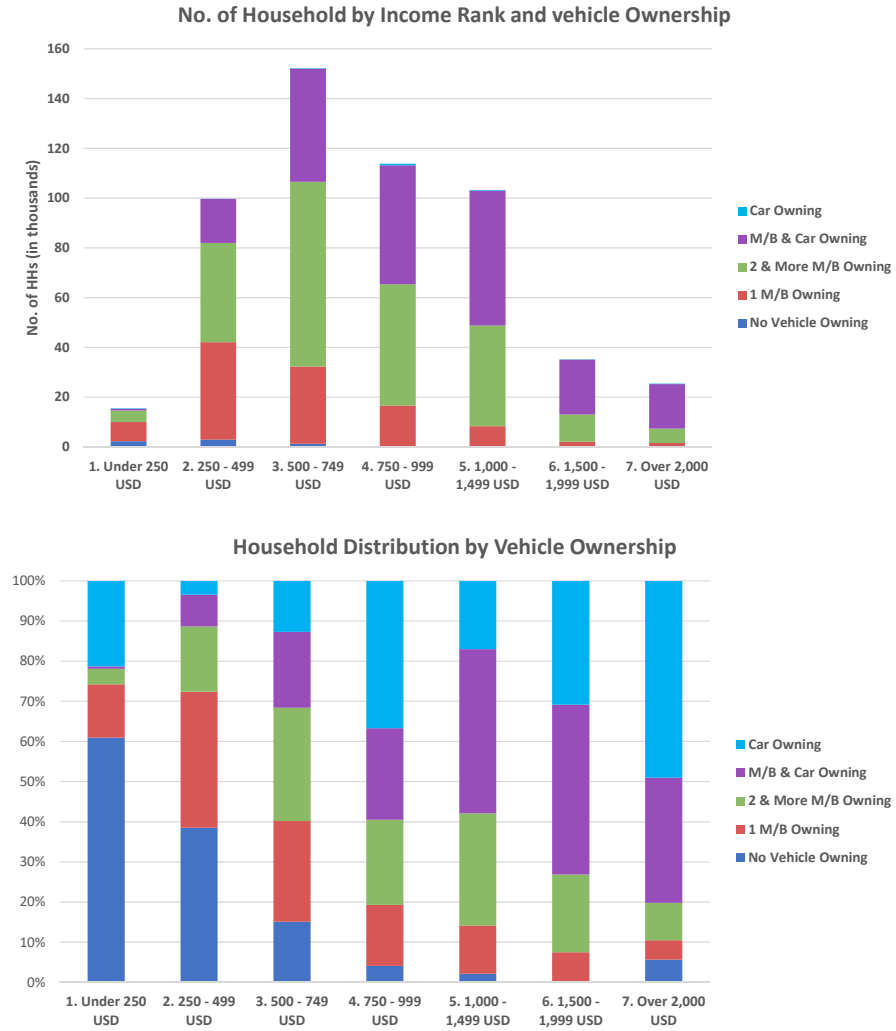
Figure 1.3.10 illustrates the distribution of households by monthly income level and household vehicle ownership by income groups in 2012. At that time, 48% of total households, or a population of 180 thousand, belong to the income group of USD 250 to USD 499 and the estimated average household is USD 468 per month. The upper graph shows a steady increase in car ownership rates with an increase in household income level. In total, the household car ownership ratio is 18.5%, while the motorbike ownership ratio is 73.8%.



Note: The results are calculated by using dataset with expansion factor from Person Trip survey.
Source: JST

Figure 1.3.10 Household Income Distribution and Vehicle Ownership in 2012

Figure 1.3.11 illustrates the results of Person Trip Survey in 2022 that approximately 28% of total households, or a population of 150 thousand, belong to the income group of USD 500 to USD 749 and 21% of total households, or a population of 113 thousand, belong to the income group of USD 750 to USD 999 (Figure 1.3.11). Therefore, the average household income is estimated at USD 872 per month. The upper graph shows a steady increase in car ownership rates with increase in household income level. In total, the household car ownership ratio is 37.8%, while the motorbike ownership ratio is 60.6%.



Note: The results are calculated by using dataset with expansion factor from Person Trip Survey.
Source: JST

Figure 1.3.11 Household Income Distribution and Vehicle Ownership in 2022

1.3.2 Cordon Line Survey (CLS)

(1) Outline

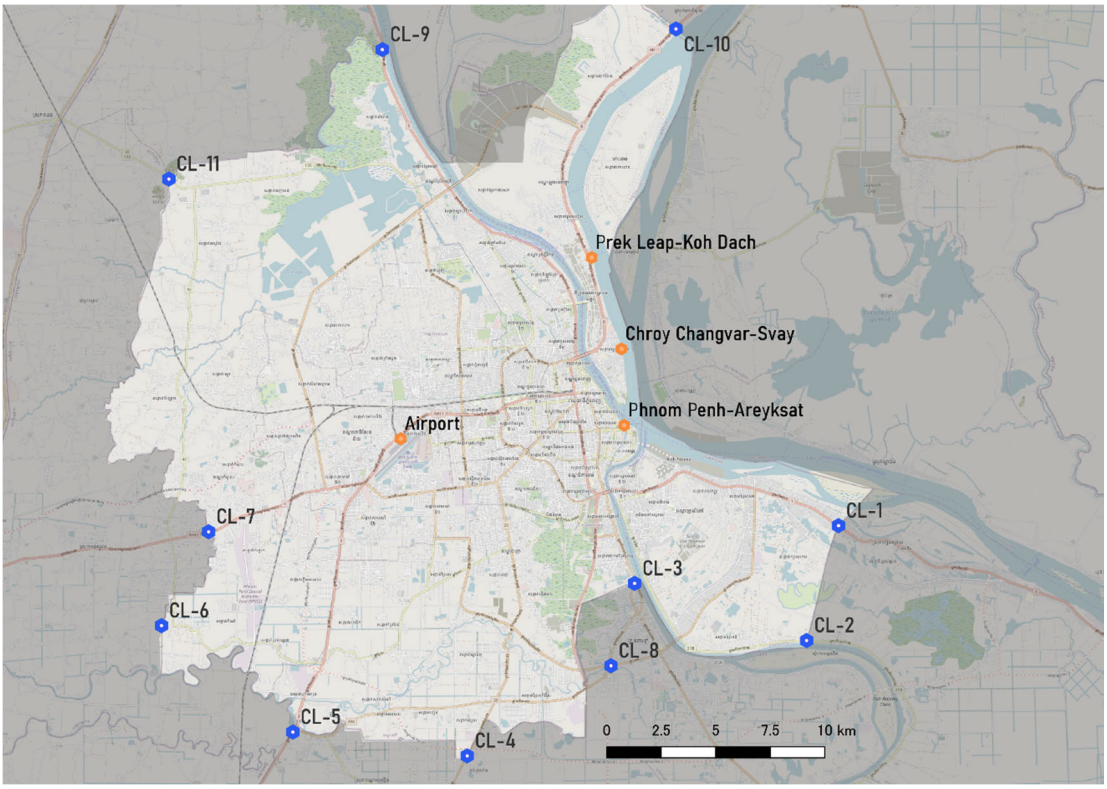
The cordon line survey aims to estimate the trips to/from the project area made by residents living outside of the project area and the freight traffic crossing the cordon lines. The estimated OD matrices based on the cordon line survey are used in the transport modelling together with the OD matrices obtained from the Person Trip survey. In order to obtain such data/information, the following surveys are conducted.

- 1) Traffic count survey
- 2) Roadside OD interview survey
- 3) Passenger interview at Airport and Ferry ports.

Table 1.3.7 List of Cordon Line Survey Locations

Survey Location	Location and Road Name	Hours
Road		
CL-01	NR-1 on Phnom Penh Capital Boundary (Kien Svay)	24
CL-02	Dike Road (Tonle Basak) (Chheu Teal)	16
CL-03	Kandal Province and Phnom Penh Boundary	24
CL-04	NR-2 on Phnom Penh Boundary (Preah Putth)	24
CL-05	NR-3 on Phnom Penh Boundary (Anlong Romiet)	24
CL-06	Prey Puok (Angk Snuol)	16
CL-07	NR-4 on Phnom Penh Boundary (Baek Chan)	24
CL-08	Chhak Chheu Neang(Angk Snuol)	16
CL-09	NR-5 on Phnom Penh Boundary (Samraong)	24
CL-10	NR-6 on at Phnom Penh Boundary (Mukh Kampul)	24
CL-11	NR-6 on Phnom Penh Boundary	24
Air/Ferry		
Airport	Phnom Penh International Airport	16
Ferry port 01	Phnom Penh - Areyksat Ferry (Phnom Penh Side)	16
Ferry port 02	Chroy Changvar - Svay Chrum Ferry (Phnom Penh Side)	16
Ferry port 03	Prek Leap - Koh Dach Ferry (Phnom Penh Side)	16

Source: JST



Source: JST

Figure 1.3.12 Map of Cordon Line Survey Locations

(2) Survey Coverage and Method

1) Traffic Count Survey

Classified vehicular counting was conducted at 14 cordon lines for both directions (11 locations on roads and 3 ferry ports). The duration of the traffic count survey was for 24 hours from 6:00 to 6:00 at 8 locations and for 16 hours from 6:00 to 22:00 at 6 other locations. The survey was conducted on weekdays (Tuesday through Thursday excluding public holidays). Also, the type of each vehicle was separately counted and the recorded for every 15-minute interval.

Table 1.3.8 Vehicle Classification

	11 Vehicle Type	9 Vehicle Type	6 Vehicle Type
1	Motorbike / Motodop	Motorcycle	Motorcycle
2	Tuk-Tuk	Tuk-tuk	Tuk-tuk
3	Motorumork	Motorumork	
4	Sedan, Wagon and Van	Sedan	Sedan
5	Taxi		
6	Mini Bus	Mini Bus	Bus
7	City Bus	Bus	
8	Medium & Large Bus		
9	Light Truck	Light Truck	Light Truck
10	Truck (2 Axles)	Truck (2axles)	Truck
11	Heavy Truck and Trailer	Heavy Truck	

Source: JST

2) Roadside and Ferry Port OD Interview Survey

The roadside OD interview was conducted for 16 hours from 6:00 to 22:00 on weekdays (Tuesday through Thursday) during which approximately 10% of the traffic were stopped at random in order to interview drivers and passengers. The information collected during the interview is summarised as follows:

(i) Drivers Interview ("Passenger" interview when the sample is motodop or tuk-tuk)

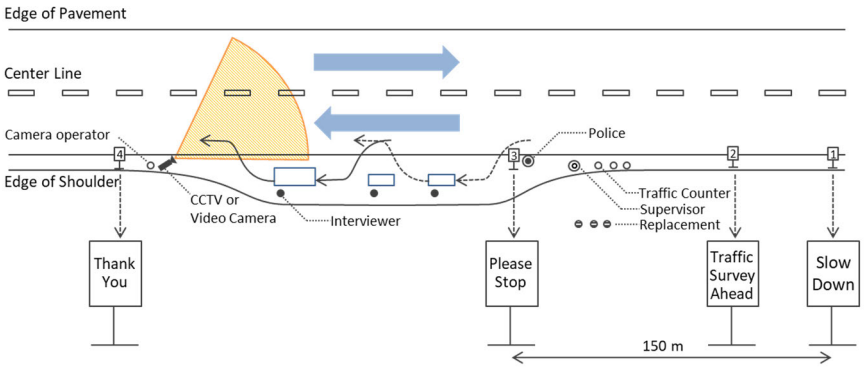
- Trip Purpose
- Origin and Destination
- Estimated travel time
- Trip frequency before/after COVID-19 pandemic
- Passenger counting(including driver)

(ii) Drivers Interview (for Truck)

- Items in (i)
- Loading item (Last item if empty)
- Maximum loading capacity
- Loading rate

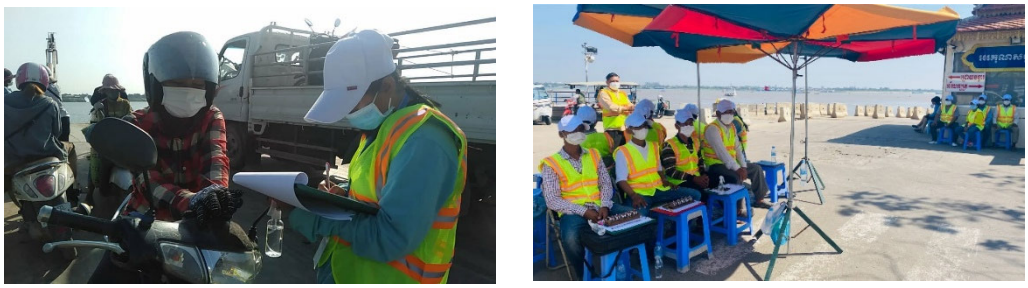
(iii) Bus Passenger Interview (for Bus)

- Items in (i)
- Access Mode from place (Origin Point) to Bus terminal
- Egress Mode from Bus terminal to Place (Destination Point)



Source: JST

Figure 1.3.13 Example of Field Implementation of Roadside Interview Survey



Source: JST

Figure 1.3.14 Implementation of Cordon Line Survey (Ferry Port)

3) Passenger Interview at Airport

The interviews were conducted for 16 hours from 06:00 to 22:00. Approximately 10% of the passengers were stopped at random for the interview.

- Items in (i)
- Access Mode from place (Origin Point) to Bus terminal
- Egress Mode from Bus terminal to Place (Destination Point)

(3) Results of Traffic Count Survey

1) Summary

A summary of the Traffic Count Survey results is shown in Table 1.3.9. Traffic results by location are shown in Figure 1.3.15. From these summary results, the following are observed:

- For the national roads which connect cities, about 9,000 - 63,000 PCU were observed.
- The peak rate is 6.8%, and the ratio of 24 hours traffic to 12 hours traffic is 1.34 in average.

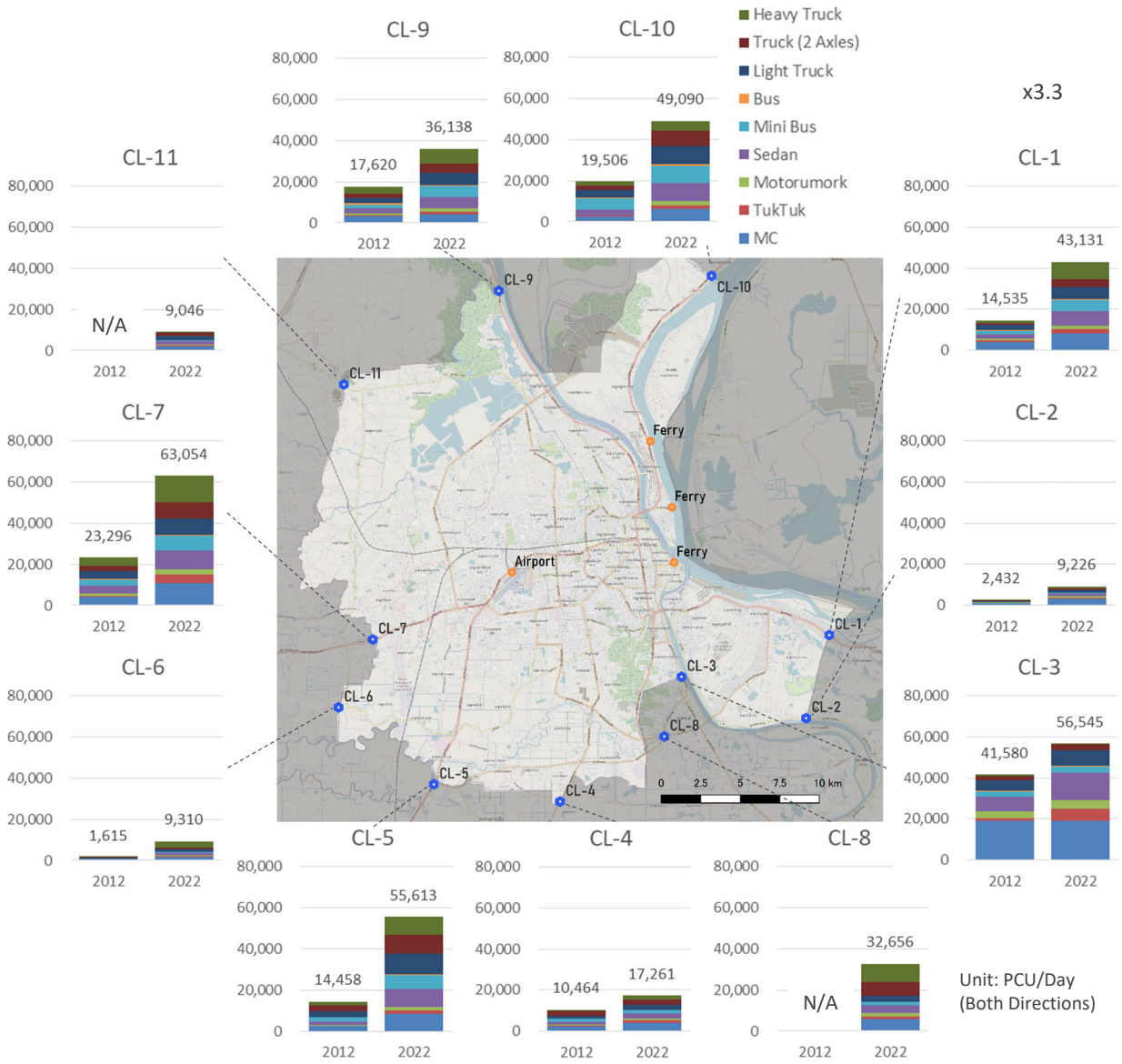
- In total, 380,657 PCU/day were observed on road side.
- Comparing with the result in 2012, Compound Average Growth Ratio (CAGR) of total traffic is 10.1%.

Table 1.3.9 Summary of Traffic Count Survey (vehicle base)

Location	2012	2022					
	Traffic Volume (PCU/day)*1	Traffic Volume (PCU/day)	Peak Ratio	Ratio of Daily Traffic	Motorbike Ratio	Three-Wheeler Ratio	Sedan Ratio
CL-1	14,535	43,131	6.1%	1.58	56%	8%	15%
CL-2	2,432	9,226	9.4%	1.18	74%	8%	7%
CL-3	41,580	56,133	7.5%	1.34	67%	12%	15%
CL-4	10,464	17,261	7.9%	1.25	61%	10%	11%
CL-5	14,458	55,613	8.2%	1.34	51%	6%	15%
CL-6	1,615	9,310	7.9%	1.18	59%	7%	12%
CL-7	23,296	63,054	6.4%	1.38	53%	11%	14%
CL-8	-	32,656	8.0%	1.25	57%	9%	11%
CL-9	17,620	36,138	6.4%	1.41	44%	8%	17%
CL-10	19,506	49,090	7.2%	1.33	45%	8%	19%
CL-11	-	9,046	7.9%	1.17	63%	6%	15%
Svay Chrum Ferry	-	5,871	11.0%	1.20	83%	7%	8%
Arey Kasat Ferry	-	7,505	10.9%	1.21	83%	8%	7%
Kohdach Ferry	-	2,686	11.6%	1.24	87%	6%	4%
Total (excluding ferry*)	145,505	380,657	6.8%	1.34	59%	9%	14%

Note: Peak rate is ratio for 24 hours. 16 hours traffic volume is converted into the 24 hours traffic volume based on the survey result of the 24 hours traffic count survey. Traffic volume of ferry port is not converted into 24 hours. 12 hours traffic volume is from 6:00 to 18:00.

Source: JST

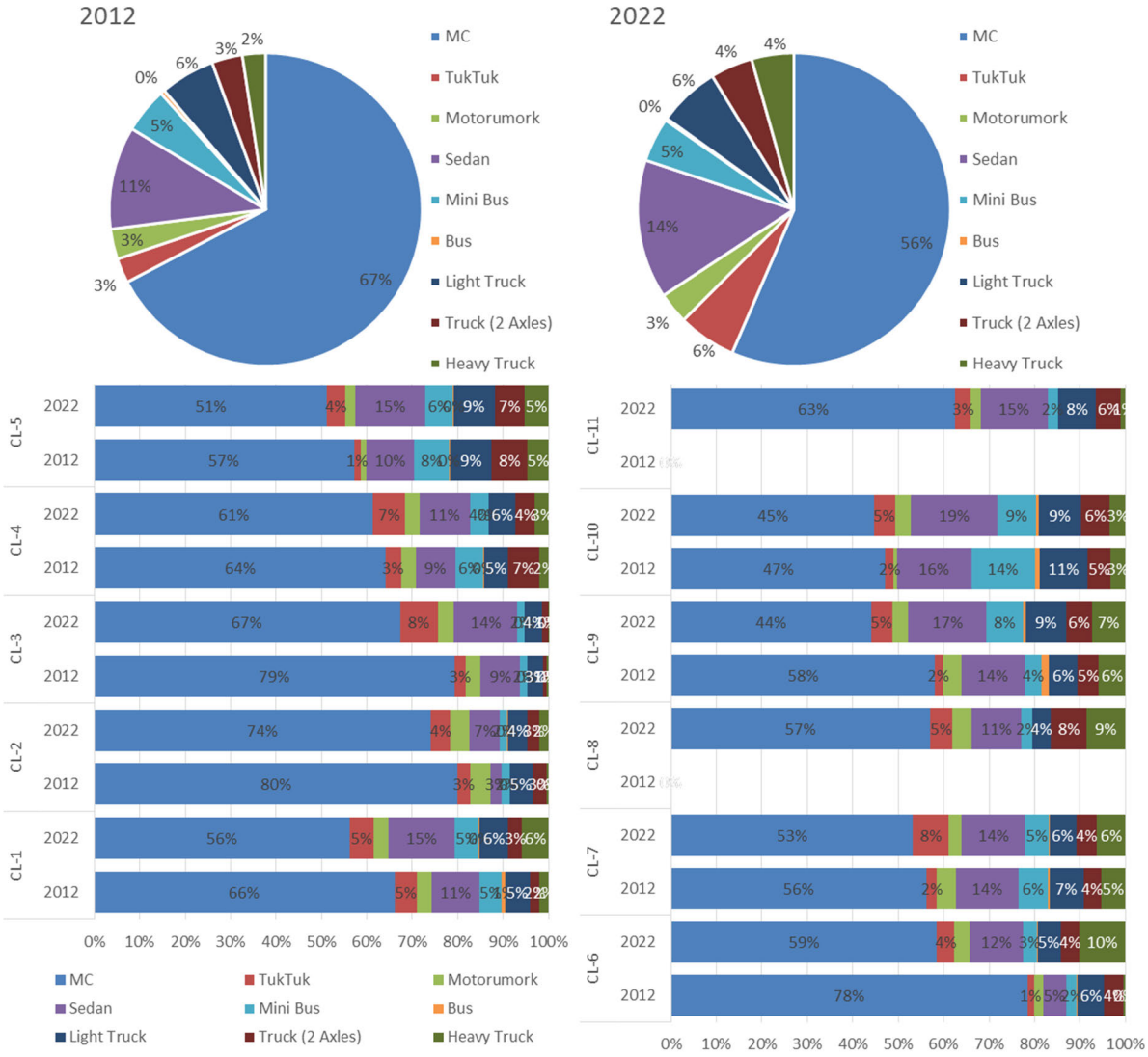


Source: JST

Figure 1.3.15 Cordon Line Traffic Volume in 2012 and 2022 (PCU base)

2) Vehicle Type Composition

Vehicle type composition is shown in Figure 1.3.16. Motorcycle has the highest share of 56% on national roads, however its share reduced compared to 67% in 2012. On the other hand, sedan and tuk-tuk increased from 11% to 14% and 3% to 6% respectively. The tendency is observed at all locations.

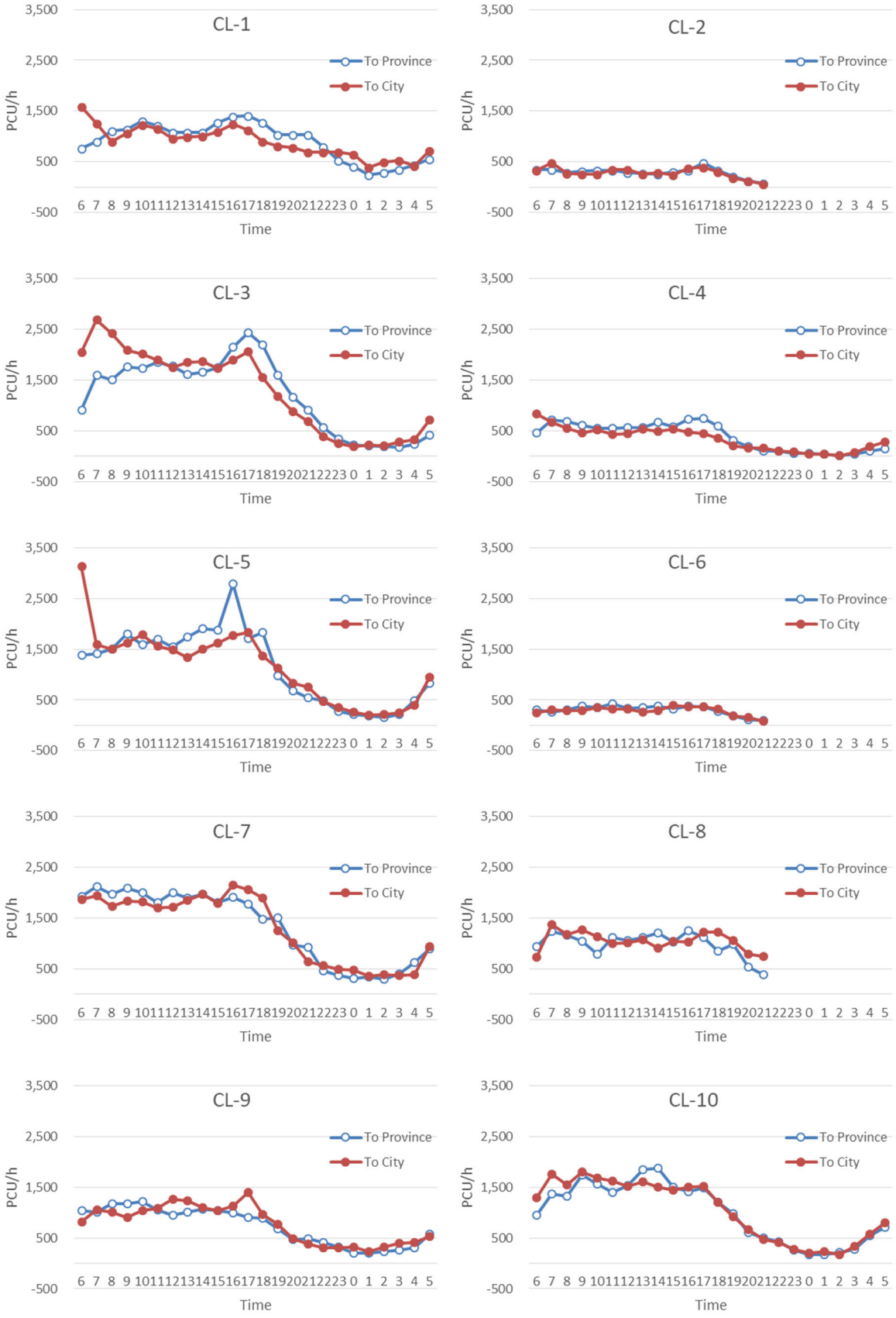


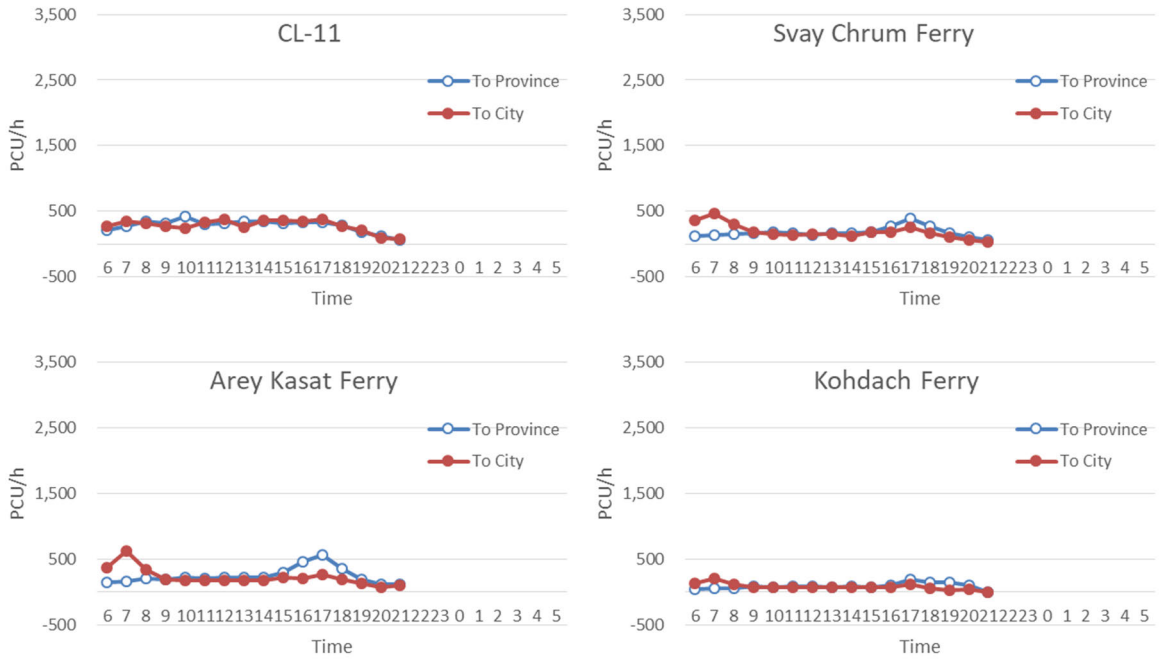
Source: JST

Figure 1.3.16 Vehicle Type Composition in 2012 and 2022 (vehicle base)

3) Hourly Fluctuation of Traffic Volume

Hourly fluctuation of traffic volume is shown in Figure 1.3.17. 7:00 to 8:00 is usually a peak hour in the city areas, but the peak hour begins at 6:00 to 7:00 outside the city areas.


CL-1
CL-2
CL-3
CL-4
CL-5
CL-6
CL-7
CL-8
CL-9
CL-10
To Province
To City
PCU/h
Time
3,500
2,500
1,500
500
-500
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5



Source: JST

Figure 1.3.17 Hourly Fluctuation of Traffic Volume by Location

(4) Results of Roadside and Ferry Port OD Interview Survey

1) Number of Samples and Sampling Rate

The number of samples and sampling rate at each station are shown in Table 1.3.10.

Table 1.3.10 Number of Samples and Sampling Rate

Sample Rate	Traffic Volume (16hrs)	No. of Samples	Sampling Rate
CL-1	43,753	1,909	4%
CL-2	14,830	1,691	11%
CL-3	94,426	2,319	2%
CL-4	20,661	2,321	11%
CL-5	52,318	1,954	4%
CL-6	9,929	1,430	14%
CL-7	63,205	1,924	3%
CL-8	34,267	1,830	5%
CL-9	30,081	1,356	5%
CL-10	43,613	1,924	4%
CL-11	11,770	1,017	9%
Svay Chrum Ferry	13,330	1,730	13%
Arey Kasat Ferry	17,145	1,877	11%
Kohdach Ferry	6,418	957	15%

Source: JST

2) Average Passenger Occupancy

The average passenger occupancy by vehicle classification is shown in Table 1.3.11. These numbers include drivers. Compared to the results in 2012, average passenger occupancy has decreased in all vehicle types.

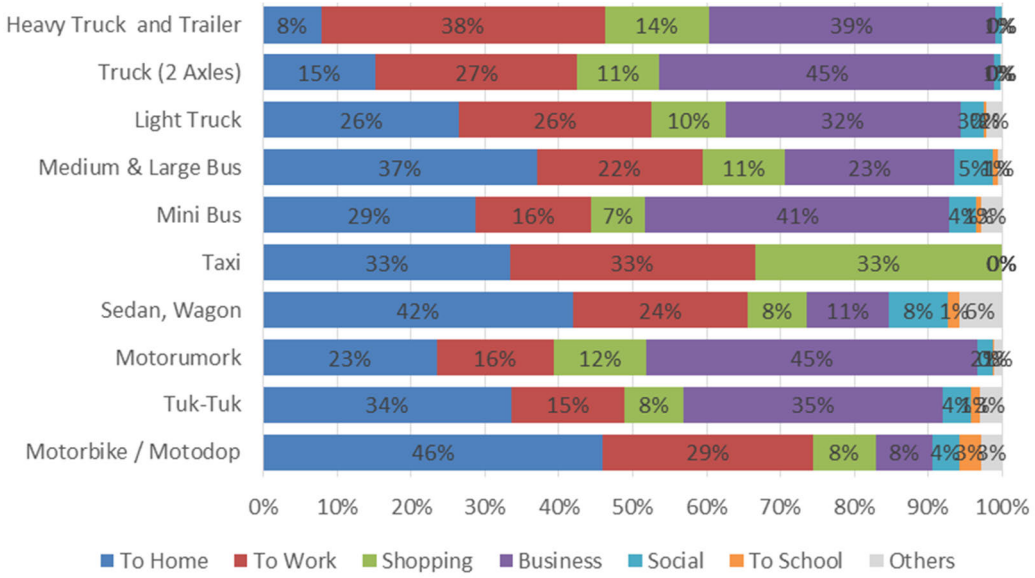
Table 1.3.11 Average Passenger Occupancy

Year	Motorbike Motodop	Tuk-Tuk	Motorumork	Sedan, Wagon	Taxi	Mini Bus	Bus	Light Truck	Truck (2 Axles)	Heavy Truck and Trailer
2022	1.3	2.1	1.8	2.3	2.0	4.4	12.0	2.4	2.2	1.5
2012	1.5	3.7	4.6	2.8	3.1	8.9	22.4	5.0	2.4	2.0

Source: JST, PPUTMP

3) Trip Purpose

Figure 1.3.18 shows the trip purpose by vehicle classification.

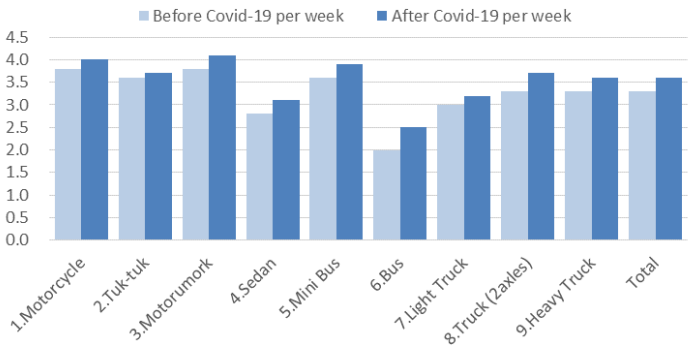


Note: Vehicle base, before expansion
Source: JST

Figure 1.3.18 Trip Purpose by Vehicle type

4) Trip Frequency Before/After COVID-19 Pandemic

Figure 1.3.19 shows trip frequency in a week before and after the COVID-19 pandemic by vehicle type. Generally, trip frequency is bit larger after the pandemic, but the difference is not significant. Buses tend to be used for lower frequency trips.

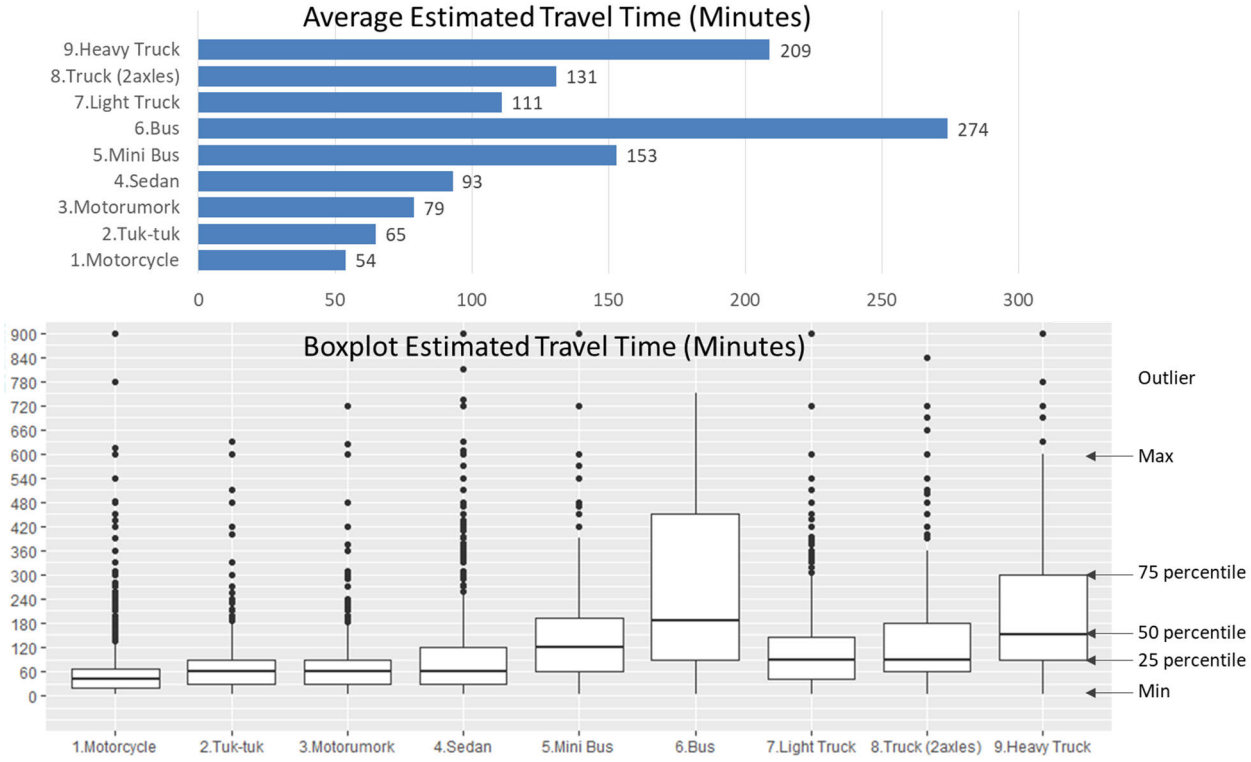


Note: Vehicle base, before expansion
Source: JST

Figure 1.3.19 Trip Frequency in a Week by Vehicle type

5) Estimated Travel Time

Figure 1.3.20 shows the estimated travel time by vehicle classification. The estimated travel time is based on the driver's estimate. Travel time for medium/ large buses and heavy trucks/ trailers were more than 200 minutes on average. The average travel time of smaller vehicles like the motorcycles, motodop and tuk-tuk is about 60 minutes.

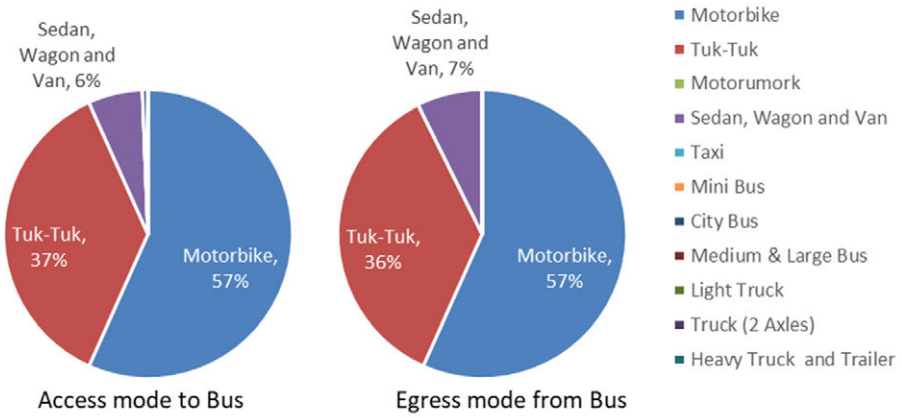


Note: Vehicle base, before expansion, 900+ omitted
Source: JST

Figure 1.3.20 Estimated Travel Time by Vehicle type

6) Access and Egress mode of Bus Passengers

Figure 1.3.21 shows access and egress mode of bus passengers. These results show that tuk-tuk plays an important role as an access/egress mode of bus.

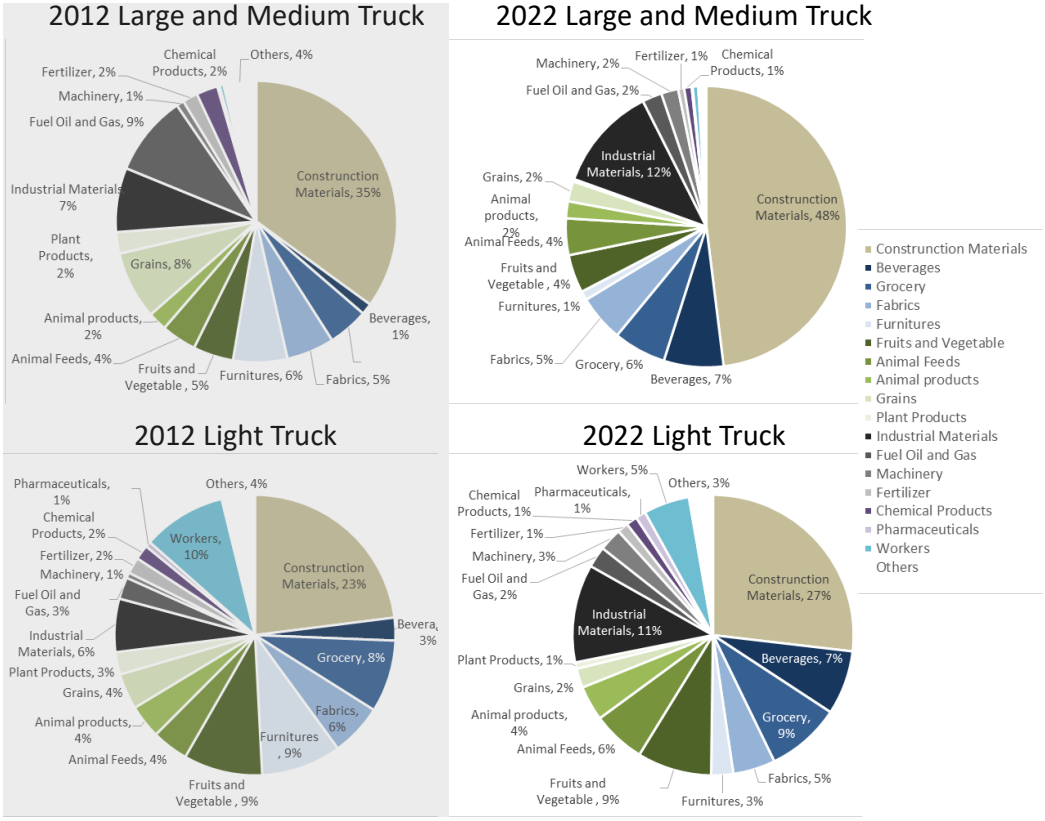


Note: Vehicle base, before expansion, 900+ omitted
Source: JST

Figure 1.3.21 Access and Egress mode of Bus Passengers

7) Major Cargoes of Trucks and Load Factor

Figure 1.3.22 shows the major cargoes carried by trucks and trailer trucks in 2022 and 2012. Cargo of construction materials accounts for 48% of large and medium trucks and 27% of light trucks at cordon lines, which increased from 35% and 23% in 2012. Other than that, industrial materials increased from 2012, in large and medium trucks 7% to 12% and in light trucks from 6% to 11%.



Note: Vehicle base, before expansion, all locations
Source: JST, PPUTMP

Figure 1.3.22 Major Cargoes of Trucks

8) Loading Rate and Loading Volume of Trucks

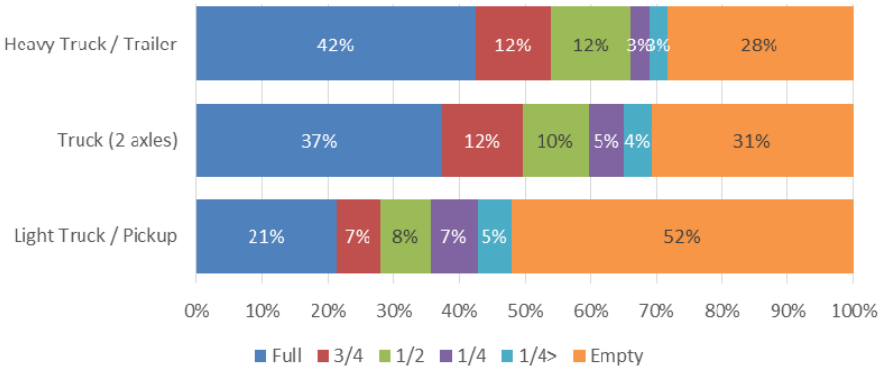
Table 1.3.12 shows the maximum loading capacity and average loading volume of trucks by truck types. The average maximum loading capacity of heavy trucks and trailers is 19.4 tons on average, while that of 2 axle trucks is 6.3 tons. The average loading volume of heavy truck and trailers is 16.1 tons and that of 2 axle trucks is 5.1 tons excluding empty trucks.

Table 1.3.12 Average Max Loading Volume and Loading Volume of Trucks (Ton)

	Avg. Max Loading Capacity	Avg. Loading (Incl. Empty)	Avg. Loading (Excl. Empty)
Heavy Truck and Trailer	19.4	11.5	16.1
Truck (2 Axles)	6.3	3.5	5.1
Light Truck & Pickup	1.5	0.6	1.2

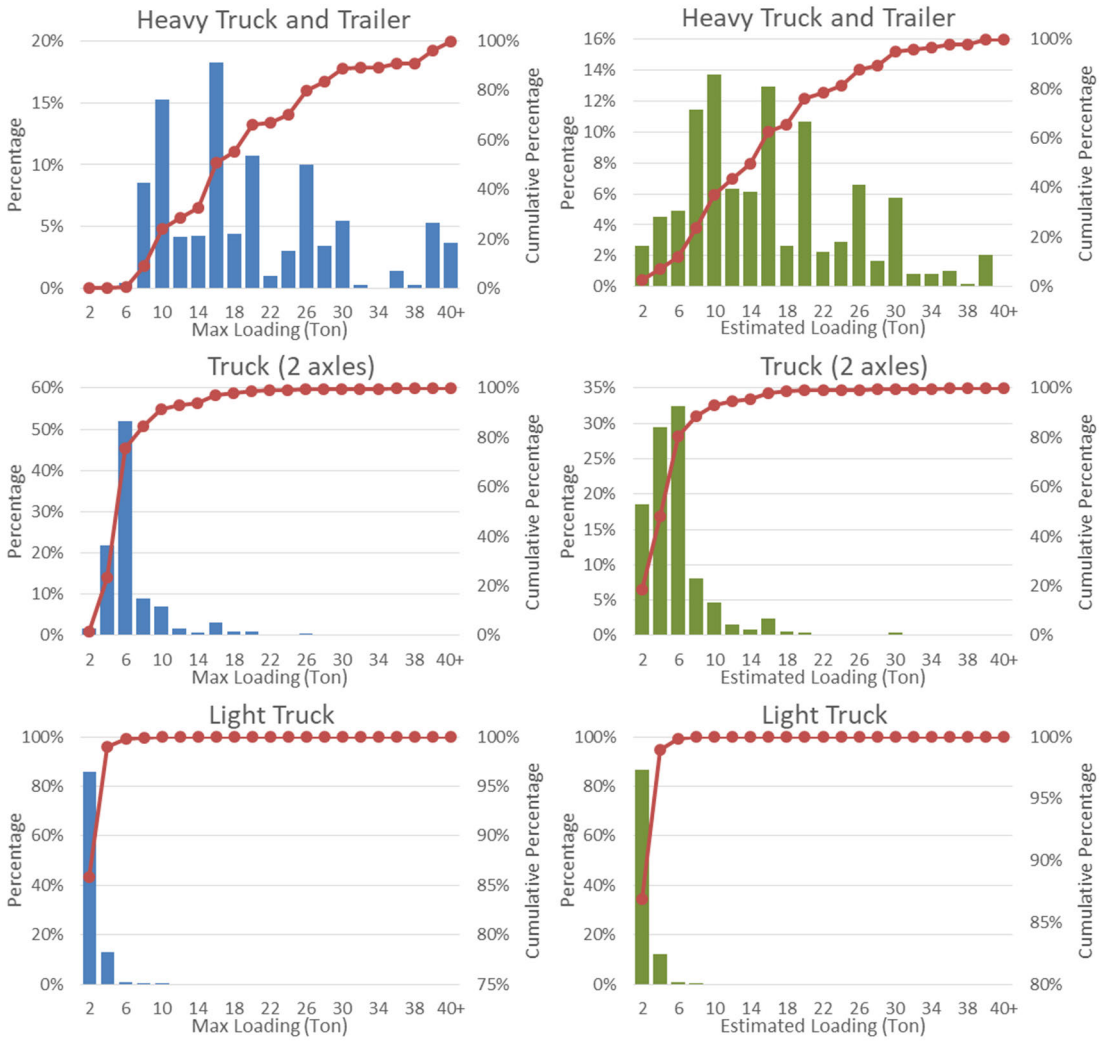
Note: Vehicle base, before expansion, all locations
Source: JST

Figure 1.3.23 shows the loading factor by truck type. In general, larger trucks have a larger loading factor. 42% of heavy trucks and trailers were fully loaded and 28% were empty. Figure 1.3.24 shows the distribution of maximum loading capacity and loading volume by truck type.



Note: Vehicle base, before expansion
Source: JST

Figure 1.3.23 Loading Factor by Truck type



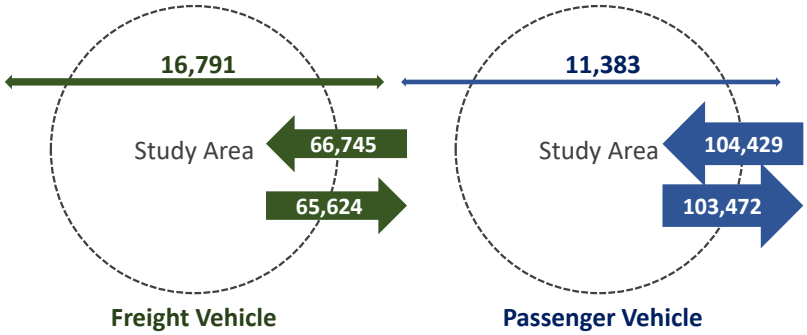
Note: Vehicle base, before expansion
Source: JST

Figure 1.3.24 Maximum Loading Capacity and Loading Volume (Ton)

9) Ratio of External-Internal and External-External

The cordon line OD is developed based on the results of OD interview survey and traffic counting survey. Figure 1.3.25 summarises the ratio of external-internal traffic and external-external traffic in PCU. In total, 340,279 PCU come in and go out to/from the study area, while 28,174 PCU just pass through. The ratio of external-external traffic is higher in freight vehicles.

	PCU/day			Share		
	Truck	Passenger Vehicle	Total	Truck	Passenger Vehicle	Total
In	66,754	104,429	171,183	45%	48%	46%
Out	65,624	103,472	169,096	44%	47%	46%
External-Internal	132,378	207,901	340,279	89%	95%	92%
External-External	16,791	11,383	28,174	11%	5%	8%



Source: JST

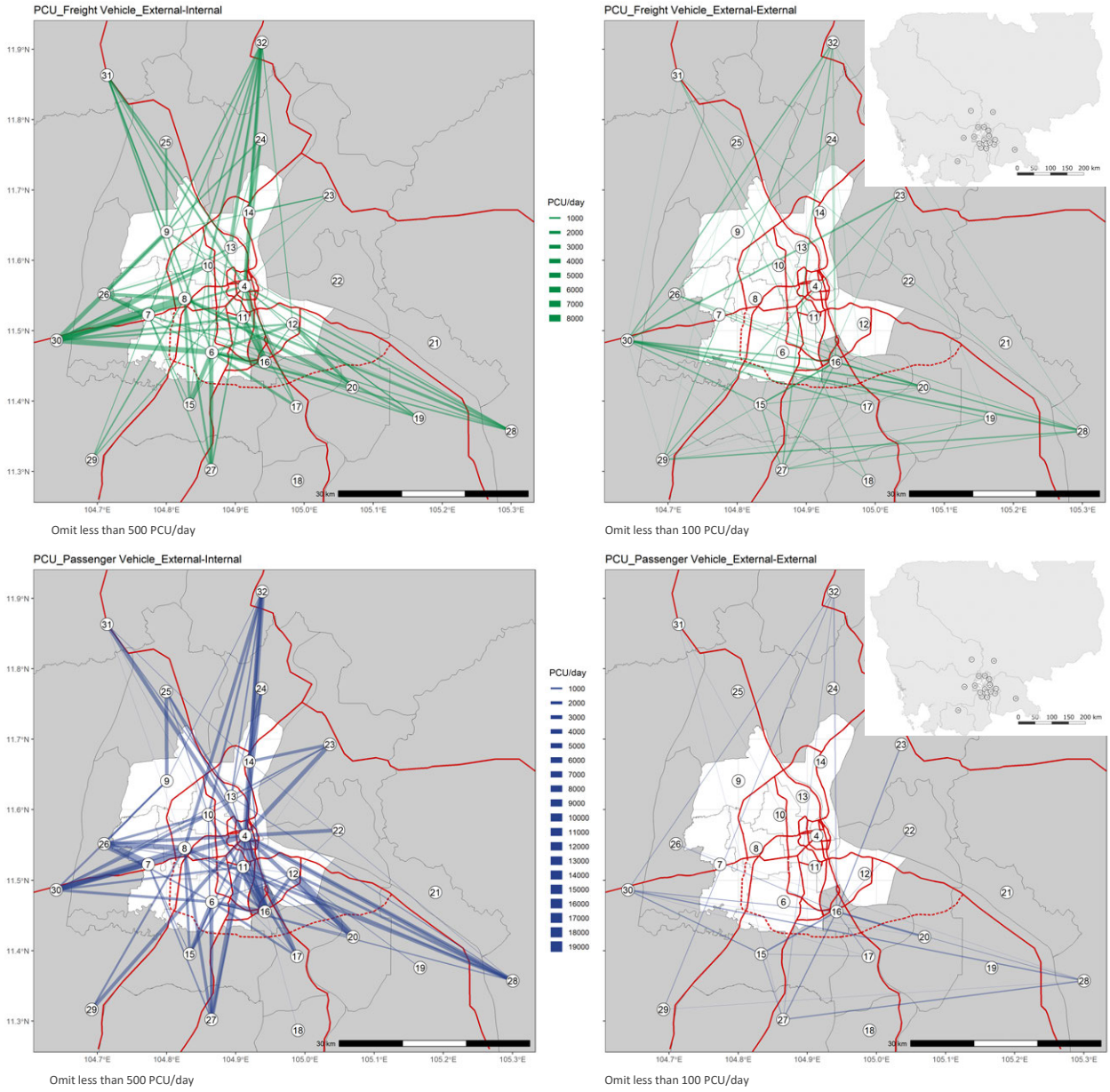
Figure 1.3.25 Ratio of External-Internal and External-External

10) Desire Line of Cordon Line OD

Figure 1.3.26 shows the desire line of cordon line OD of freight traffic (green) and passenger traffic (blue).

In the graph of external-internal freight traffic, strong lines are observed between NR-4 and the outskirt of west and south-west of Phnom Penh. In the graph of external-external freight traffic, strong lines are observed between NR-4 and NR-1, followed by NR-4 and NR-6. This result indicates that the completion of the south part of RR-III could contribute to the mitigation of traffic congestion along Veng Sreng Blvd. or RR-II. However, freight traffic to/from large zone 8 will stay on Veng Sreng Blvd. and Russian Blvd. even after the completion of the RR-III.

In the graph of external-internal passenger traffic, strong lines are observed into the large zone 4, CBD area, from all directions. Even though large zones 6, 8 or 12 attract some amount of cordon passenger traffic, the majority of them concentrate inside CBD. The cordon passenger traffic to/from CBD is large enough to affect the congestion level of the radial arterial roads. On the other hand, external-external passenger traffic volume is small.



Note: PCU base
Source: JST

Figure 1.3.26 Desire Line of Cordon Line OD

(5) Results of Airport OD Interview Survey

1) Number of Samples and Sampling Rate

Table 1.3.13 shows the number of passengers arriving and departing to/from the airport. On the date the survey was conducted, February 15 2022, only international flights were operated and the number of international flights was smaller than usual because of the effects of COVID-19. The number of arriving passengers was 929 and that of departing passenger was 645. The interview sample rate was 36% for arriving passengers and 39% for departing passengers.

Table 1.3.13 Number of Samples and Sampling Rate at Airport

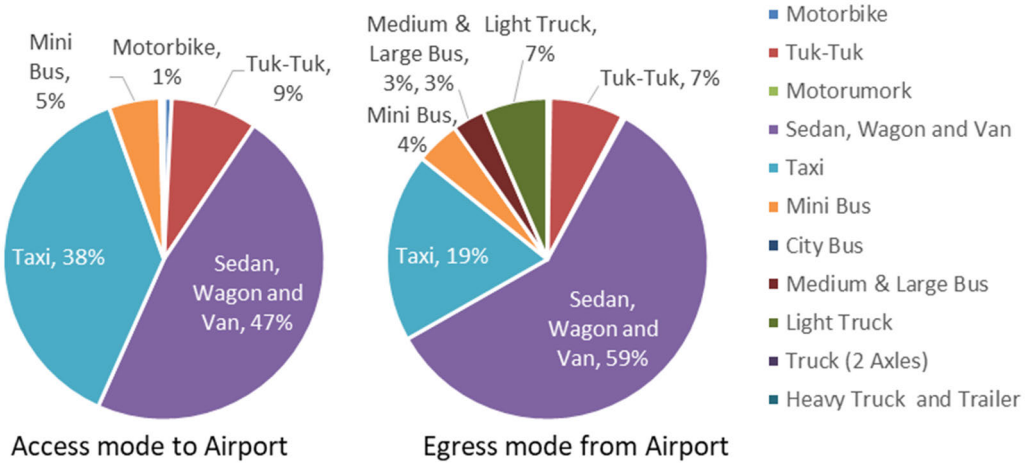
International Arrival			
No.	Time	Flight Name	Passenger on Board
1	9:10	SIN-PNH	141
2	9:45	BKK- PNH	77
3	13:05	BKK- PNH	46
4	15:10	HCM-PNH	57
5	17:11	HCM-PNH	66
6	17:30	SIN-PNH	131
7	18:20	BKK- PNH	125
8	22:09	ICN- PNH	178
9	23:10	ICN- PNH	108
Total			**929**
Interview Sample			**337**
Sample Rate			**36%**

International Departure			
No.	Time	Flight Name	Passenger on Board
1	9:55	PNH-BKK	52
2	10:55	PNH-BKK	103
3	11:15	PNH-SIN	92
4	17:40	PNH-HCM	28
5	18:35	PNH-SIN	110
6	19:25	PNH-BKK	122
7	23:45	PNH-ICN	138
Total			**645**
Interview Sample			**254**
Sample Rate			**39%**

Source: JST

2) Access and Egress Mode

Figure 1.3.27 shows the access and egress mode to/from the airport. Sedan shares the largest percentage at 47% for access and 59% for egress followed by taxi and tuk-tuk.

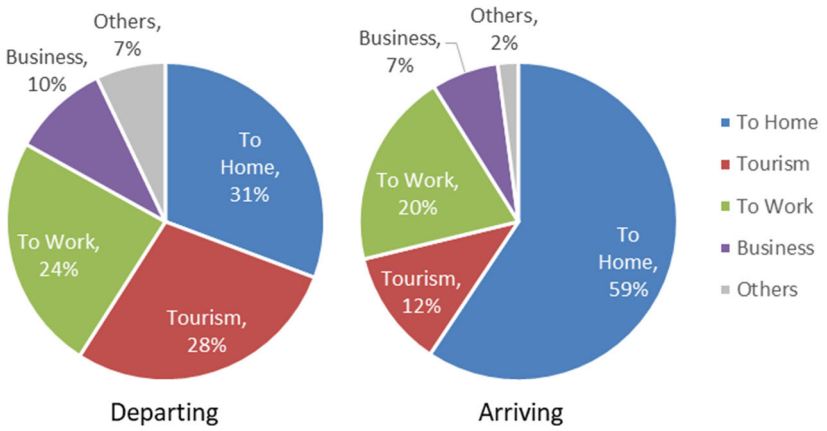


Source: JST

Figure 1.3.27 Access and Egress Mode to/from Airport

3) Trip Purpose of Departing and Arriving Passengers

Figure 1.3.28 shows the purpose of international airport trips. The trip purpose of foreigners and local people can be estimated based on the results. The trip purpose of departing passengers, except for “to home”, could reflect the trip purpose of local people. Business and to work purpose shares 34% and tourism shares 28%. The trip purpose of arriving passengers, except for “to home”, could reflect the trip purpose of foreign people. Compared to departing passengers, the share of tourism is smaller.



Source: JST

Figure 1.3.28 Trip Purpose of Departing and Arriving Passengers

1.3.3 Screen Line Survey (SLS)

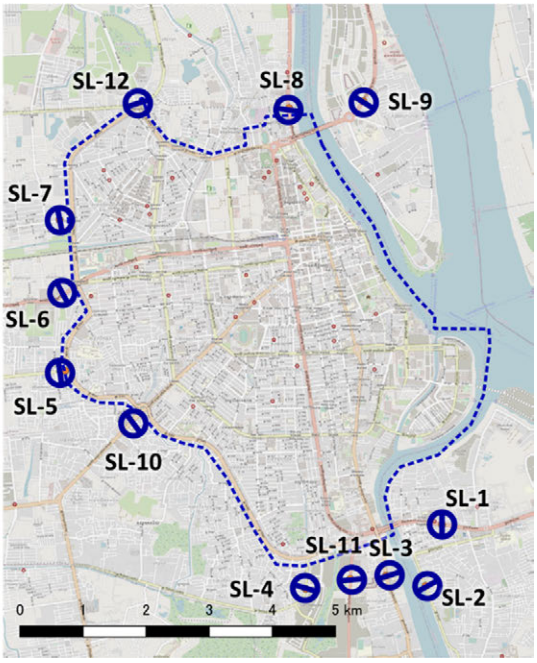
(1) Outline

The objective of the Screen Line Survey (SLS) is to grasp the traffic volume crossing the screen line, boundary of the CBD area, and gather information for the calibration of the estimated current OD matrices.

(2) Survey Coverage

- The survey was conducted at 12 locations on arterial roads crossing the screen line in the project area (see Figure 1.3.29). Out of 12 locations, three locations (SL-6, SL-10 and SL-12) were covered in the Intersection Traffic Count Survey.
- Classified vehicular counting was conducted on both traffic directions at 5 locations for 24 hours from 6:00 to 6:00 and the other 7 locations for 16 hours from 6:00 to 22:00 on a weekday (from Tuesday to Thursday) between January and March 2022.
- Vehicle occupancy survey was conducted at 4 locations (SL-2, SL-4, SL-5 and SL-7), randomly selecting vehicles at the site and counting the number of passengers in the vehicle including the driver.

Location	Road Name	Hours
SL-1	National Road No.1	24
SL-2	Road No.369	16
SL-3	National Road No.2	24
SL-4	Road Tumnop Thmei	16
SL-5	Road 2004	16
SL-6	Russian Blvd.	16
SL-7	Road 1986	16
SL-8	National Road No.5	24
SL-9	National Road No.6	24
SL-10	Monireth Blvd.	16
SL-11	Hun Sen Blvd.	24
SL-12	Camko Roundabout	16



Note: SL-6, SL-10 and SL-12 were covered in Intersection Traffic Count Survey
Source: JST

Figure 1.3.29 **Screen Line Survey Locations Map**

Vehicular classification and the passenger car unit of each vehicle type are shown in the table below:

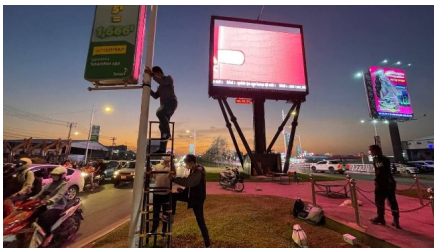
Table 1.3.14 **Vehicle Classification**

Vehicle Type	PCU
1. Motorcycle	0.3
2. Tuk Tuk (3 Wheelers)	0.75
3. Motorumok	1.25
4. Passenger Car	1
5. Taxi	1
6. Minibus (8-15 seats)	2
7. City Bus (~40 passengers)	3
8. Medium & Large Bus (16+ seats)	3
9. Light Truck (<4 Tons) & Pick Up (For Goods Only)	2
10. Medium Truck (>4 tons)	2.5
11. Heavy Truck and Trailer (Rigid 3 axles or more)	3

Source: JST

(3) Survey Method

Video images of road traffic will be recorded during the survey period by using CCTV or handy video camera. By observing the video, classified vehicular count by direction will be conducted and recorded in fifteen (15) minutes intervals.



Installation of CCTV camera

Video image of CCTV camera

Source: JST

Figure 1.3.30 Implementation of Screen Line Survey

(4) Survey Results

1) Summary of Screen Line Survey Results

Table 1.3.15 shows the summary of the Screen Line survey results. In total, 768,000 PCU/day were observed. Even though there is an additional survey location, Hun Sen Blvd., the observed traffic were largely increased compared with the observed traffic in 2012. The Compound Average Growth Ratio (CAGR) of total traffic is 2.9%.

SL-1 (NR-1), SL-6 (Russian Blvd.), SL-9 (NR-6) and SL-10 (Monireth Blvd.) have about 100,000 PCU/day traffic in both ways. Compared to the results in 2012, traffic volume has increased in many locations. Peak ratio at screen lines varies 7% to 13%.

Table 1.3.15 Summary of Screen Line Survey Results

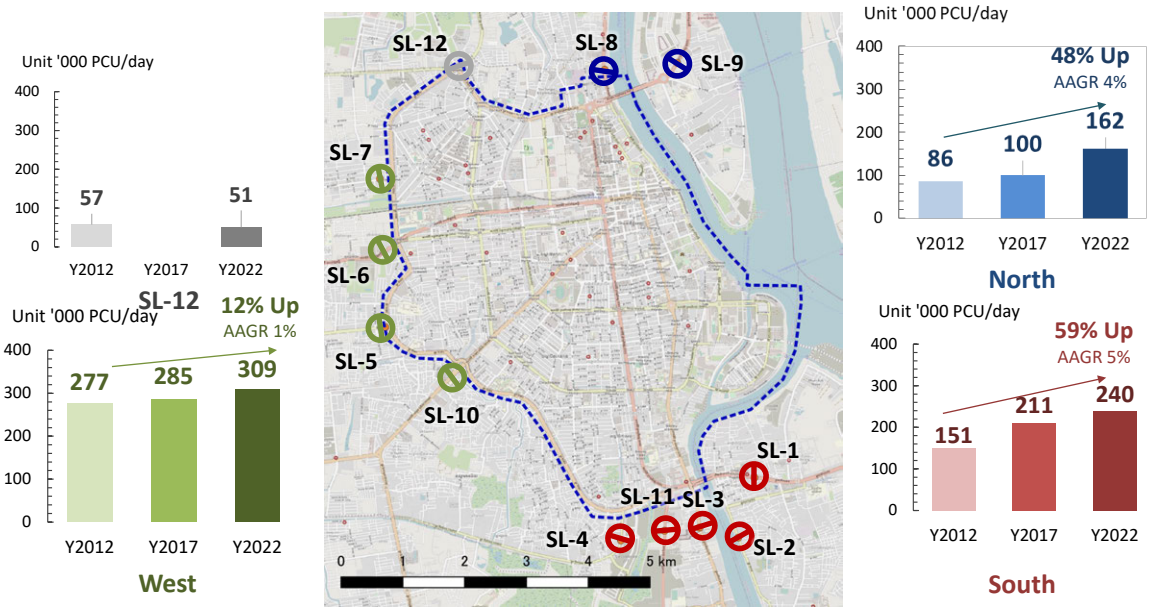
		2012	2022					
Location	Road Name	Traffic Volume (PCU/day) *1	Traffic Volume (PCU/day)	Peak Ratio*2	Ratio of Daily Traffic*3	Motorbike Ratio	Three-Wheeler Ratio*4	Sedan Ratio
SL-01	National Road No.1	43,323	95,798	7.0%	1.42	62%	11%	20%
SL-02	Road No.369	14,781	21,865	8.6%	1.35	78%	11%	8%
SL-03	National Road No.2	65,850	48,874	10.7%	1.35	74%	11%	11%
SL-04	Road Tumnop Thmei	26,743	29,603	8.7%	1.41	65%	15%	12%
SL-05	Road 2004	50,408	55,863	8.8%	1.42	65%	15%	15%
SL-06	Russian Blvd.	84,852	101,402	10.5%	1.34	70%	11%	14%
SL-07	Road 1986	39,333	50,448	9.8%	1.37	66%	14%	16%
SL-08	National Road No.5	45,703	56,376	9.1%	1.40	67%	13%	14%
SL-09	National Road No.6	40,138	105,355	8.2%	1.41	61%	11%	19%
SL-10	Monireth Blvd.	107,893	108,281	9.3%	1.34	69%	15%	10%
SL-11	Hun Sen Blvd.	-	43,659	12.7%	1.37	58%	13%	21%
SL-12	Camko Roundabout	57,352	46,663	9.4%	1.25	58%	11%	22%
Total		**576,376**	**768,176**	**9.0%**	**1.38**	**66%**	**13%**	**15%**

Note: *1 Both direction total.
*2 Peak Ratio is for 24 hours. The larger peak ratio in in-bound and out-bound direction is shown here.
*3 24 hours traffic / 12 hours traffic
*4 Tuk-tuk + Motorumo

Source: JST

2) Growth of Traffic Volume by Direction

Figure 1.3.31 shows the summarised traffic volume by direction in 2012, 2017 and 2022. The traffic volume from/to the south direction shows the largest increase of 59% (CAGR=5%) in the last 10 years, followed by that of from/to the north direction of 48% (CAGR=4%). Compared to them, the traffic volume from/to the west direction shows a smaller increase of 12% (CAGR=1%), but it has still the largest volume, 309,000 PCU/day.

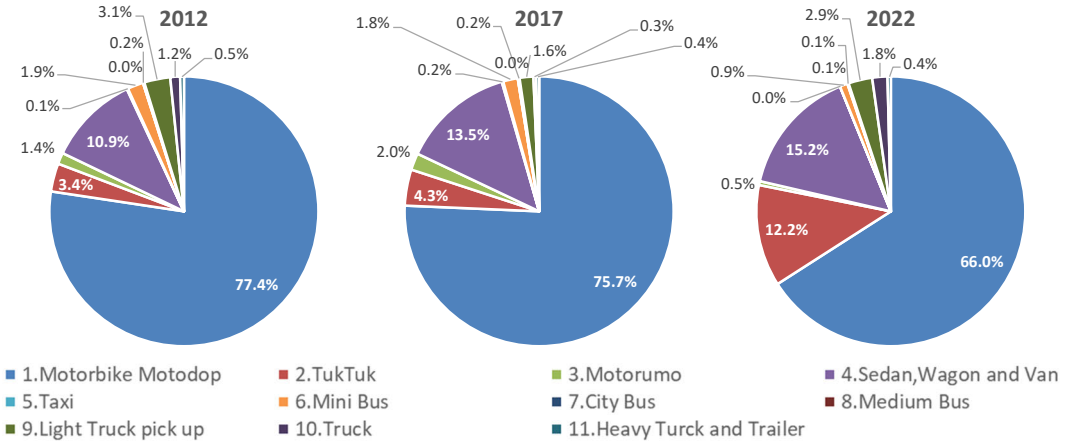


Source: JST

Figure 1.3.31 Growth of Traffic Volume

3) Vehicle Type Composition by year

Figure 1.3.32 shows the composition of vehicle type observed in the screen line survey by year. In 2012, motorcycle occupied 77.4% of the total traffic, but it decreased to 66.0% in 2022. On the other hand, tuk-tuk increased from 3.4% to 12.2% and sedan increased from 10.9% to 15.2% between 2012 and 2022.



Note: vehicle base
Source: JST

Figure 1.3.32 Composition of Vehicle Type by Year at All locations

4) Average Passenger Occupancy in Screen Line Survey

The average passenger occupancy by vehicle classification is shown in Table 1.3.16. These figures include drivers.

Table 1.3.16 Average Passenger Occupancy in Screen Line Survey

1.Motorbike Motodop	2.TukTuk	3.Motorumo	4.Sedan, Wagon and Van	5.Taxi	6.Mini Bus	7.City Bus	8.Medium Bus	9.Light Truck pick up	10.Medium Truck	11.Heavy Truck and Trailer
1.54	3.76	4.58	2.76	5.27	8.93	22.42	22.42	5.00	2.38	2.04

Source: JST

5) Average Operation Ratio in Screen Line Survey

The average operation ratio, the observed vehicle ratio with passenger, by vehicle classification is shown in Table 1.3.17.

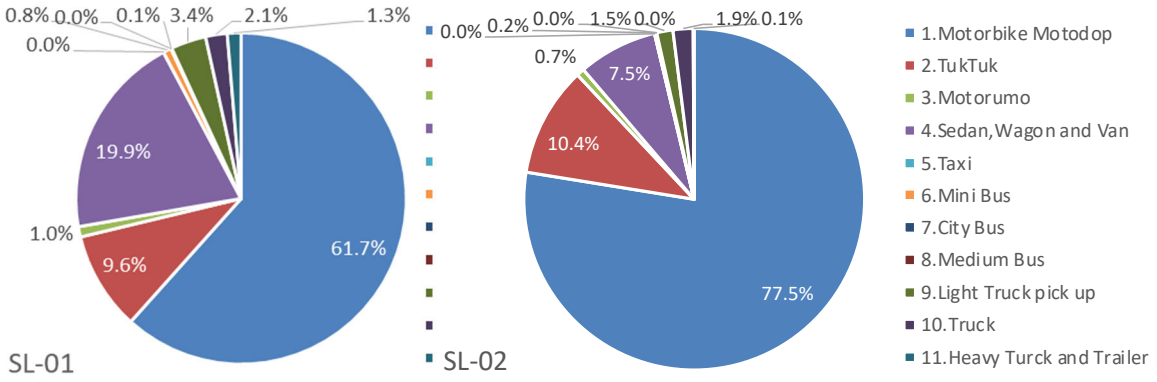
Table 1.3.17 Average Operation Ratio in Screen Line Survey

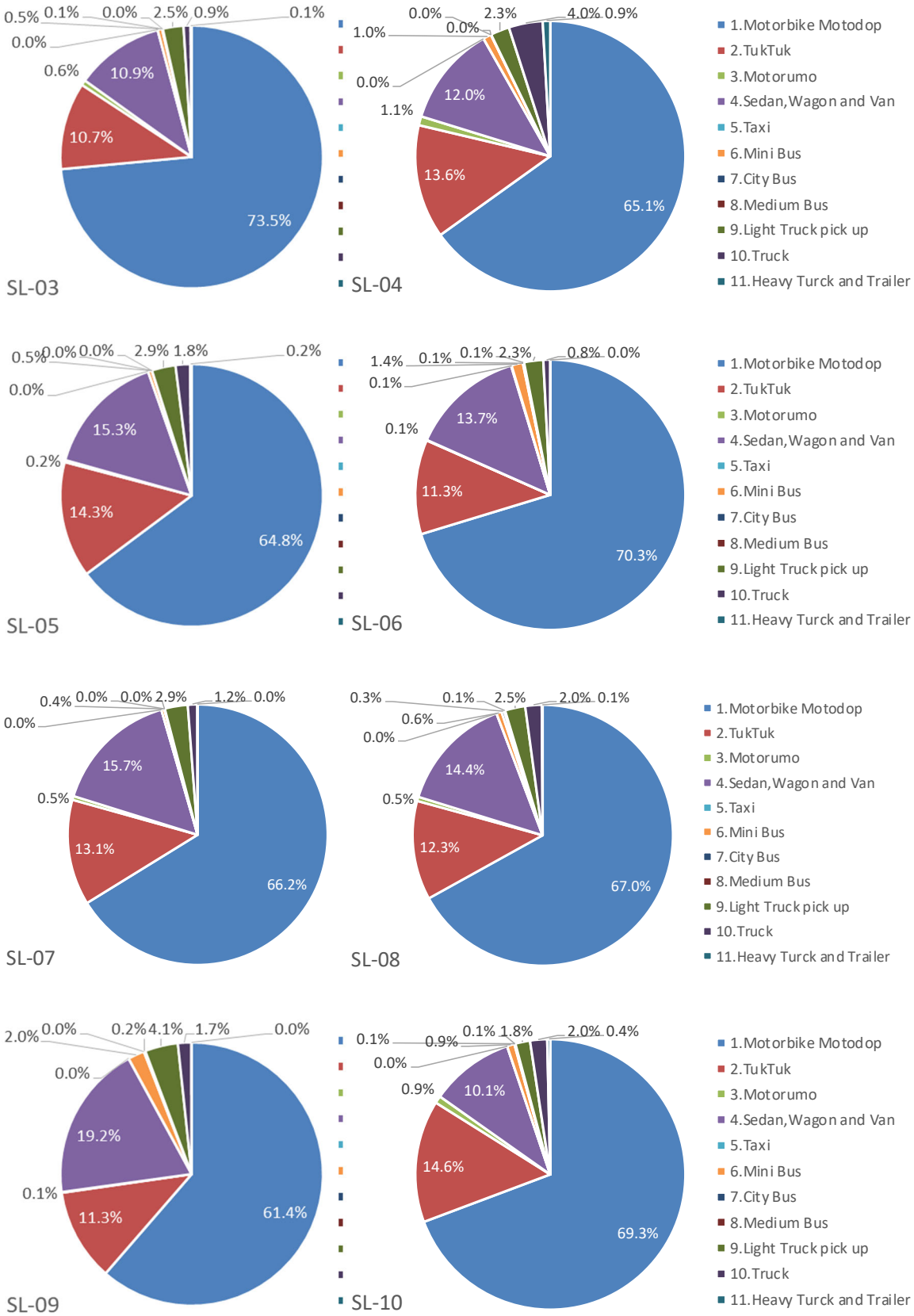
	2.Tuk-tuk	3.Motorumo	5.Taxi
Average Operation Ratio	45%	58%	47%

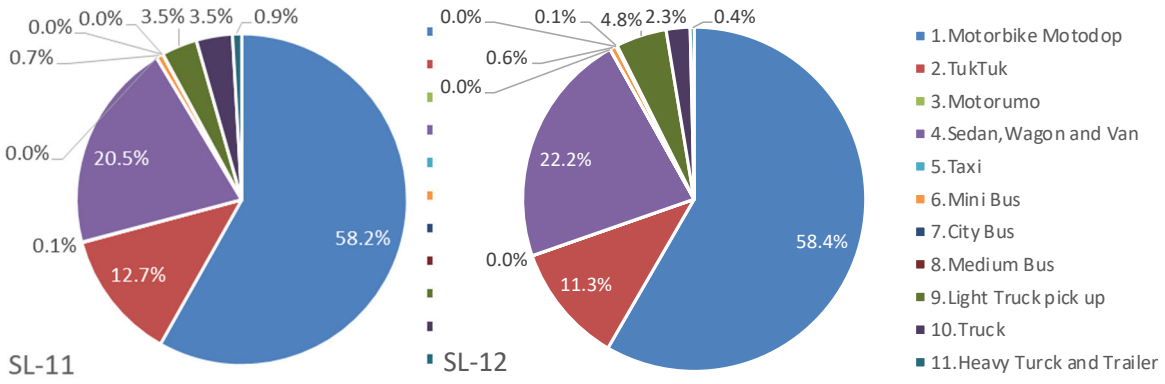
Source: JST

6) Composition of Vehicle Type by Survey Location

Figure 1.3.33 shows the composition of vehicle type by survey location. In general, ratio of sedan, wagon and van is higher at SL-01, SL-09 and SL-11, reaching about 20% of total traffic volume. The percentage of tuk-tuk is about 10~15% at all locations.




0.5%
0.1%
0.0%
2.5%
0.9%
0.1%
0.0%
0.6%
10.9%
10.7%
73.5%
SL-03
0.0%
2.3%
4.0%
0.9%
1.0%
0.0%
0.0%
1.1%
12.0%
13.6%
65.1%
SL-04
0.5%
0.0%
0.0%
2.9%
1.8%
0.2%
0.0%
0.2%
15.3%
14.3%
64.8%
SL-05
1.4%
0.1%
0.1%
2.3%
0.8%
0.0%
0.1%
0.1%
13.7%
11.3%
70.3%
SL-06
0.4%
0.0%
0.0%
2.9%
1.2%
0.0%
0.0%
0.5%
15.7%
13.1%
66.2%
SL-07
0.3%
0.1%
2.5%
2.0%
0.1%
0.6%
0.0%
0.5%
14.4%
12.3%
67.0%
SL-08
2.0%
0.0%
0.2%
4.1%
1.7%
0.0%
0.0%
0.1%
19.2%
11.3%
61.4%
SL-09
0.1%
0.9%
0.1%
1.8%
2.0%
0.4%
0.0%
0.9%
10.1%
14.6%
69.3%
SL-10
1.Motorbike Motodop
2.TukTuk
3.Motorumo
4.Sedan,Wagon and Van
5.Taxi
6.Mini Bus
7.City Bus
8.Medium Bus
9.Light Truck pick up
10.Truck
11.Heavy Turck and Trailer



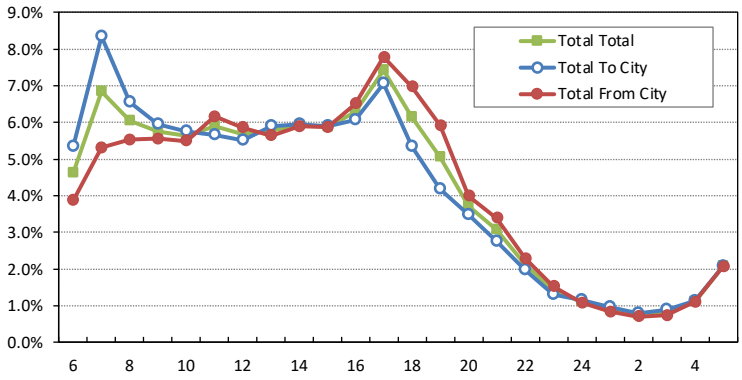
Note: vehicle base
Source: JST

Figure 1.3.33 Composition of Vehicle Type by Survey Location

7) Hourly Fluctuation by Survey Location

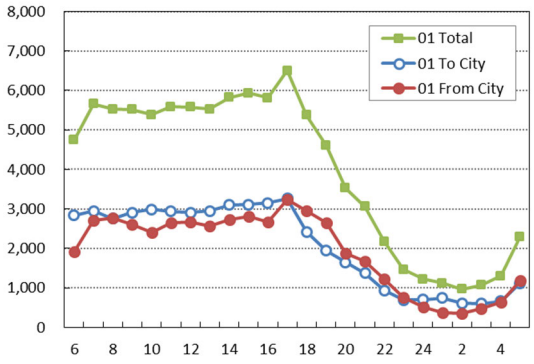
Figure 1.3.34 shows the hourly fluctuation of total traffic volume observed at all screen line survey locations. The peak ratio in the morning peak was 8.3% between 7:00~8:00 in the city direction and that the evening peak was 7.8% between 17:00~18:00 from the city direction.

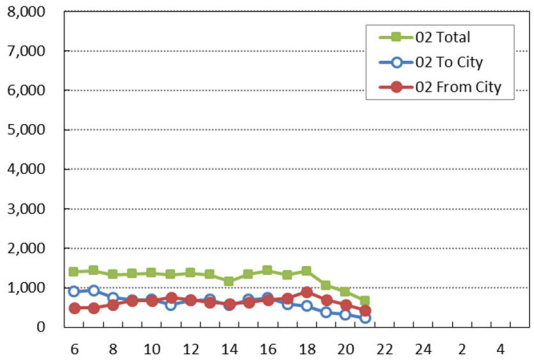
Figure 1.3.35 shows the hourly fluctuation of traffic volume at each survey location.

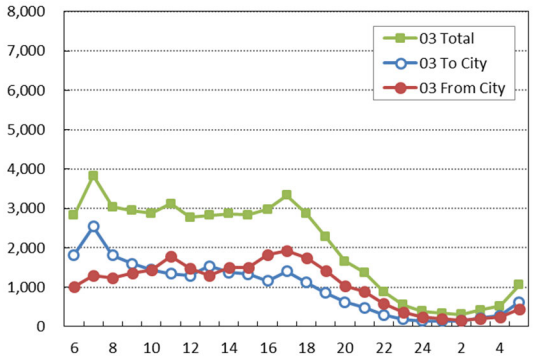


Note: Percentage based on observed and estimated 24 hours traffic volume in PCU
Source: JST

Figure 1.3.34 Hourly Fluctuation


01 Total
01 To City
01 From City
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
6 8 10 12 14 16 18 20 22 24 2 4


02 Total
02 To City
02 From City
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
6 8 10 12 14 16 18 20 22 24 2 4


03 Total
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4,000
3,000
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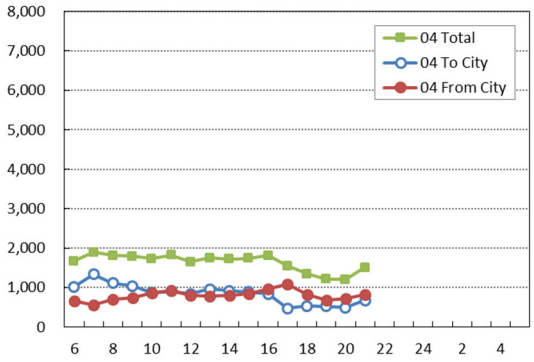
6 8 10 12 14 16 18 20 22 24 2 4


04 Total
04 To City
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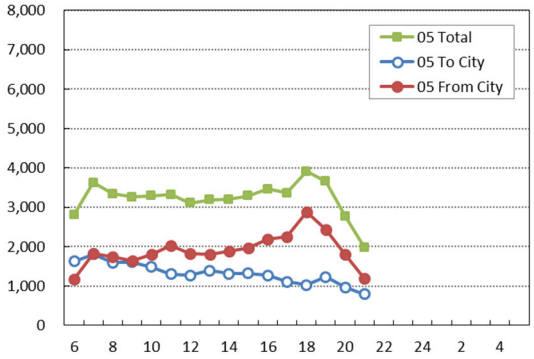
05 Total
05 To City
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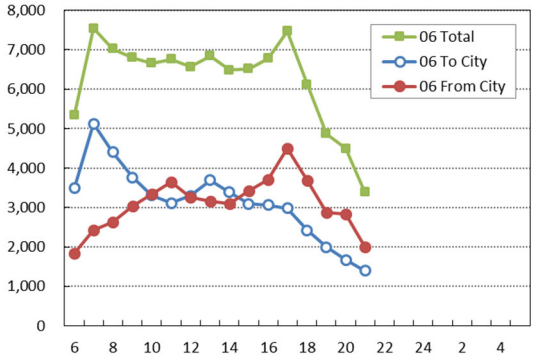
6 8 10 12 14 16 18 20 22 24 2 4


06 Total
06 To City
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8,000
7,000
6,000
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3,000
2,000
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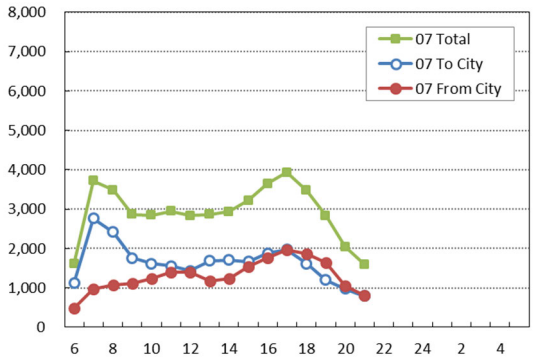
6 8 10 12 14 16 18 20 22 24 2 4


07 Total
07 To City
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8,000
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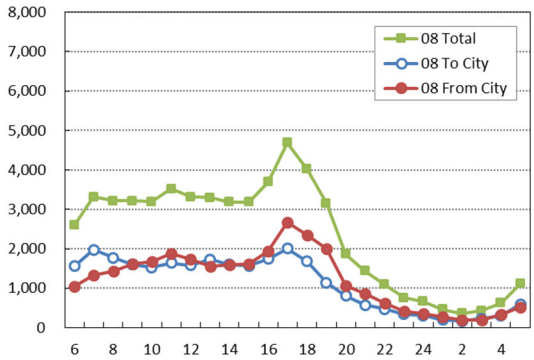
6 8 10 12 14 16 18 20 22 24 2 4


08 Total
08 To City
08 From City
8,000
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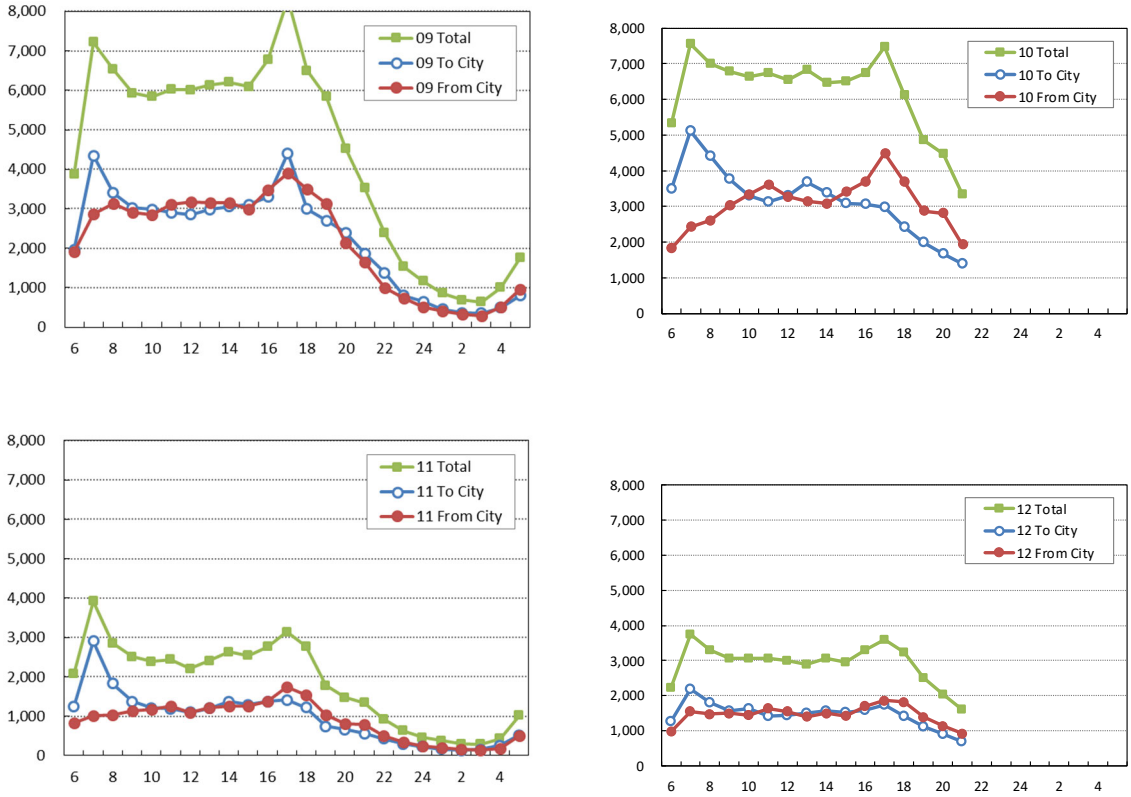
6 8 10 12 14 16 18 20 22 24 2 4



Unit: PCU/hour
Source: JST

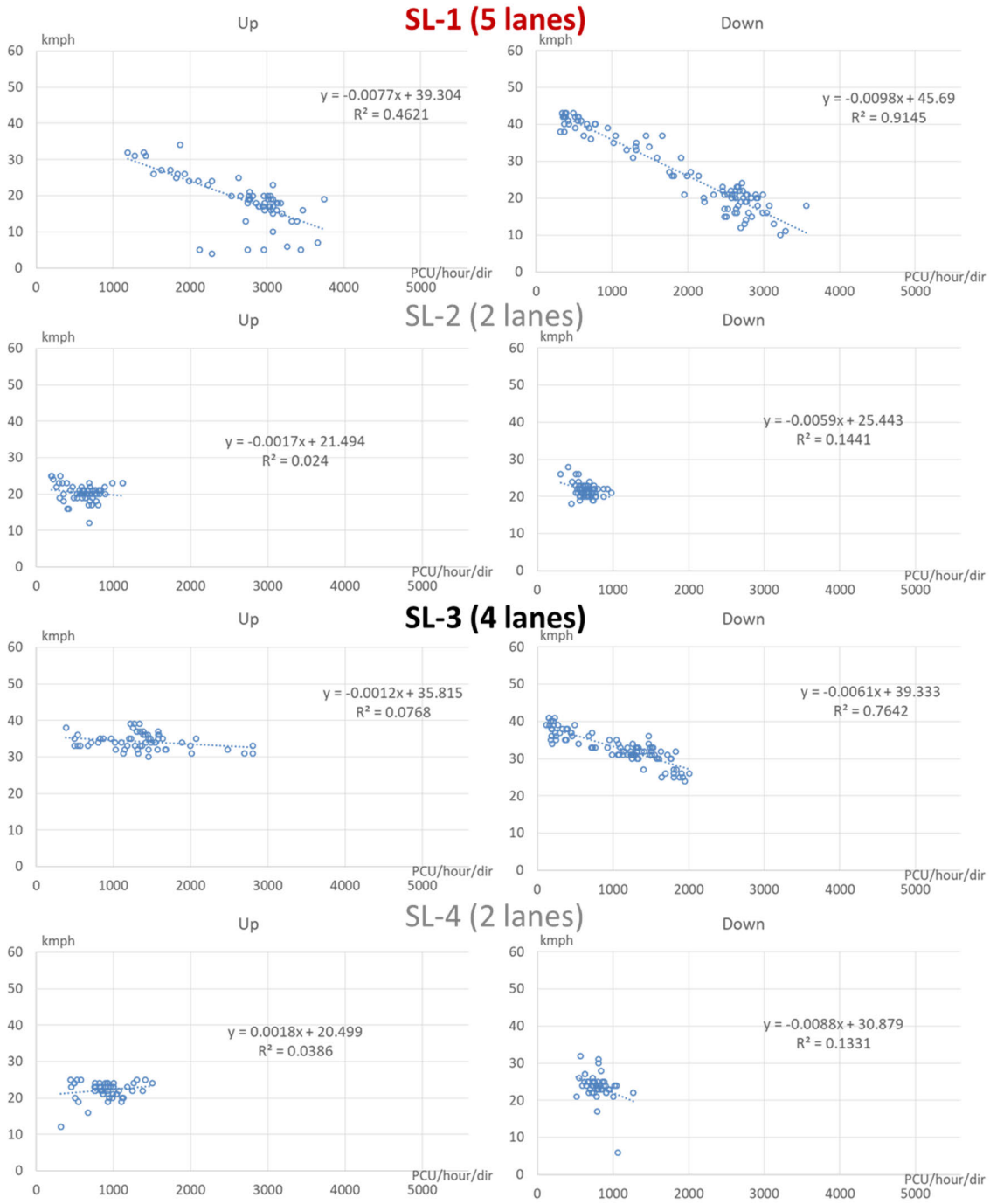
Figure 1.3.35 Hourly Fluctuation by Survey Location

8) Relation of Traffic Volume and Speed

Figure 1.3.36 to Figure 1.3.38 show the relation of traffic volume and speed which were observed in every 15 minutes. The traffic volume is converted into the PCU/hour/dir. The speed is based on Google Maps traffic condition information. About 1 km section outside the screen line is selected and the travel speed is corrected by using API.

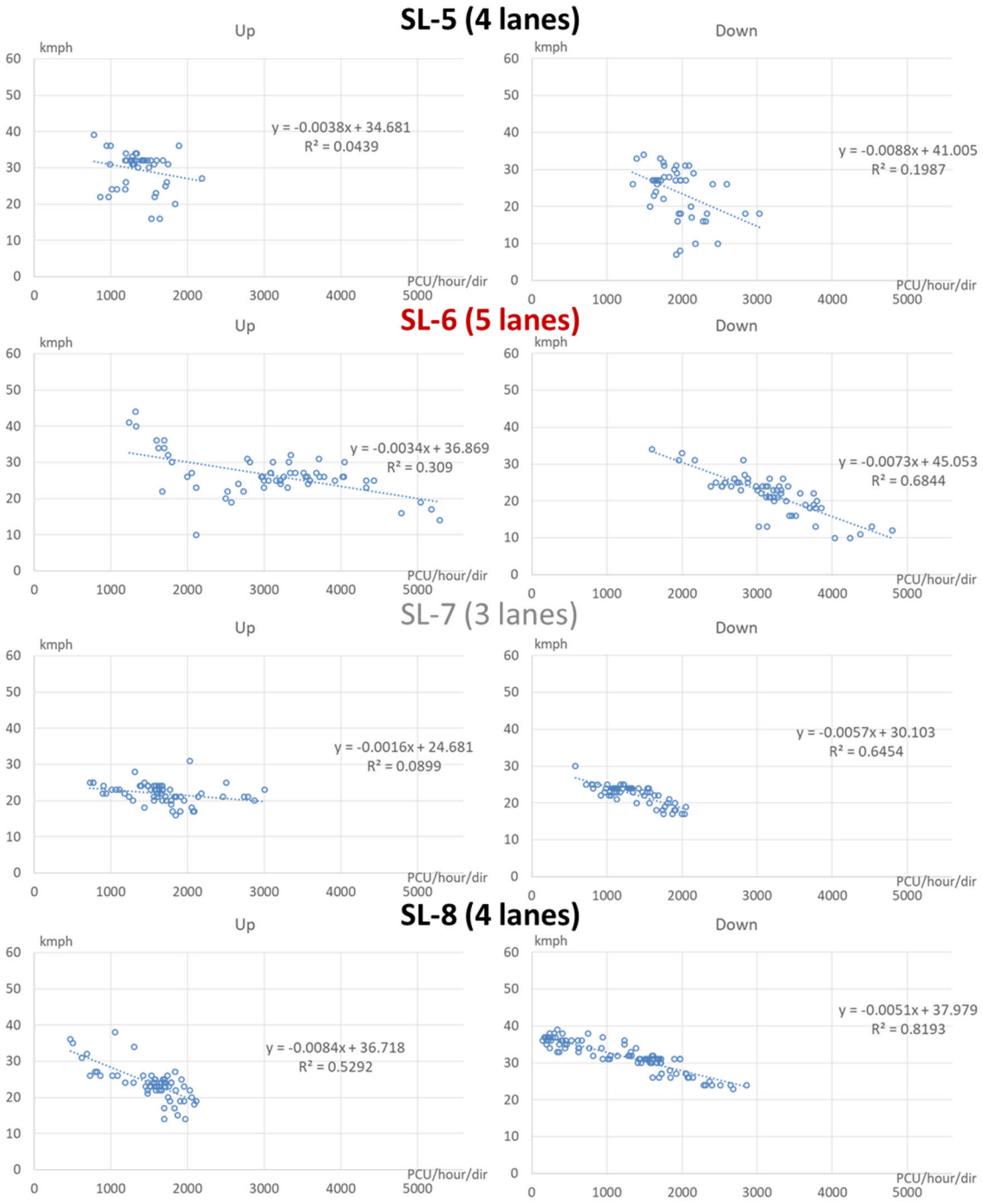
At some locations, clear negative correlations were observed between traffic volume and speed. In other locations, the correlation was not clear possibly because of the effect of the bottlenecks upstream or downstream or because traffic volume was too small to make traffic congestion.

The locations where the number of lanes is 4 or 5, the hourly capacity is estimated about 4,000~5,000. The free flow speed of locations with 4 to 5 lanes is about 40~50 km/h.



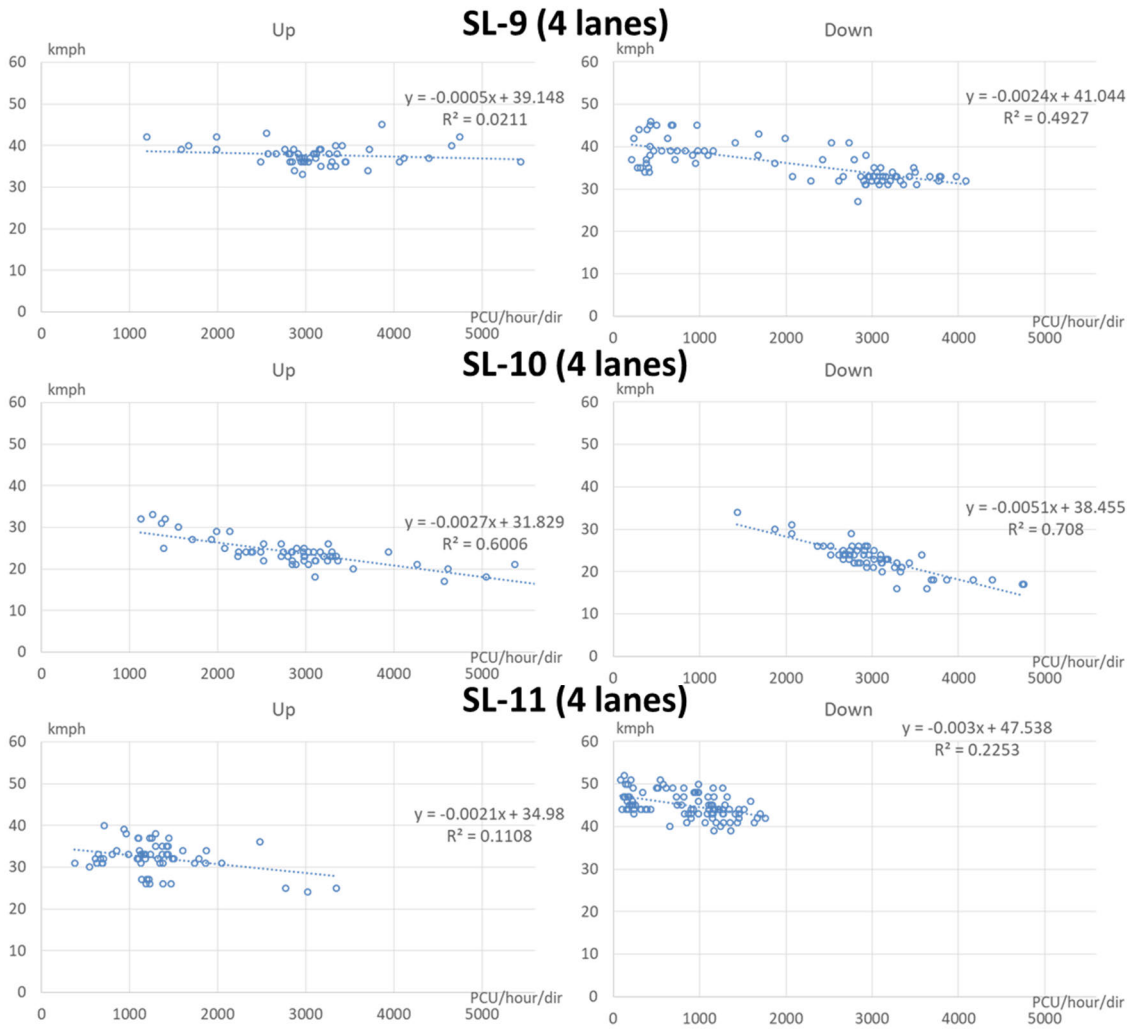
Source: JST

Figure 1.3.36 Relation of Traffic Volume and Speed (SL-1~4)



Source: JST

Figure 1.3.37 Relation of Traffic Volume and Speed (SL-5~8)



Source: JST

Figure 1.3.38 Relation of Traffic Volume and Speed (SL-9~11)

1.3.4 Passenger Interview Survey (PIS)

(1) Outline

The objective of the Passenger Interview Survey is to obtain information on the personal attributes, the preference for transport mode choice, and the opinion on the current transport situation in Phnom Penh. The survey result will be used to formulate the urban transport policy. The survey was conducted for targeting the following mode passengers.

- 1) Private Car, Motorcycle user (CAR, MC)
- 2) RHS passenger (RHS)
- 3) Public Bus passenger (BUS)
- 4) Commuter Bus passenger (CBT)

(2) Survey Coverage

1) Private Car, Motorcycle Users (CAR, MC)

The survey was conducted along four corridors in Phnom Penh in different locations including Phsar Tauch Market, Chrang Chamreh Market, Noromall, Chbar Ampov Market, Borey Penh Huot Beoung Snor, Pochentong Market, Century Plaza, Derm Kor Market, City Mall, Phnom Penh International University and Olympia Mall on weekdays of January 2022. The total samples were 519 for private car users and another 529 samples for the private motorcycle users. The respondents are drivers who are getting on/off from their vehicle near the parking space of the survey locations.

2) RHS Passenger (RHS)

The survey locations of RHS interview took place in market/mall zones (Chrang Chamreh Market, Phsar Tauch Market, Central Market, Chbar Ampov Market, Steung Mean Chey Thmei Market, Deum Kor Market, Century Plaza, Pochentong Market and AEON Mall 1). The number of respondents was 517 samples. The survey was conducted on weekdays of November 2021.

3) Public Bus Passenger (BUS)

The survey was conducted along the City Bus lines during their operation hours and at bus stops. Only 4 routes, i.e., Line 1, Line 2, Line 3, and Line 4A/4B, were in operation in January 2022.

The total samples for the Public Bus passenger is 205 samples for the 4 operational routes (targeting 40 samples per bus route). The respondents were interviewed inside the bus.

4) Commuter Bus Passenger (CBT)

The survey was conducted in PPSEZ, Vattanac industrial zone, Phsar Kamboul, Oudem, Trapaing Toul and Veng Sreng. Commuter bus includes buses, vans and trucks which are used for commuter transport of the factory employees. In total 416 samples were collected in March and April 2022.

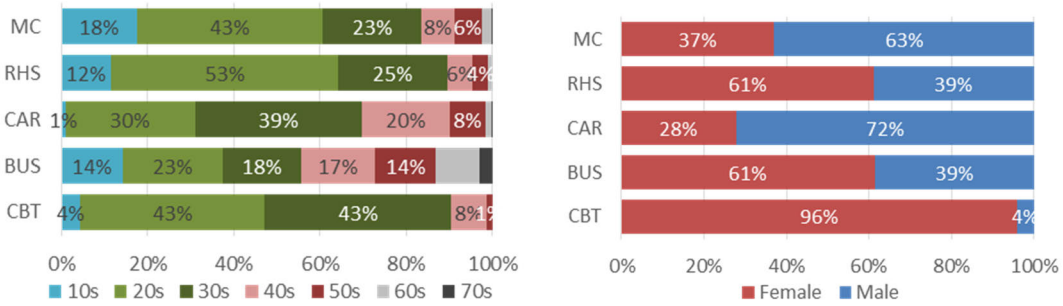
(3) Results of Passenger Interview Survey (Personal Attributes)

This section summarises the personal attributes of passengers of each transport mode. The results indicate the characteristics of transport mode in terms of passengers' personal attributes. The surveys were conducted at different locations by transport mode to efficiently collect the samples of each mode. Therefore, the difference in survey location may affect the survey results.

1) Age and Sex

The left side of Figure 1.3.39 shows the ratio of passenger's age group by mode. The ratio of young generation (10s, 20s) is larger in MC (61%) and RHS (65%), while it is smaller in CAR (31%). BUS is used by all generations including elder people.

The right side of Figure 1.3.39 shows the female/male percentage by mode. The percentage of female is larger in RHS (61%), BUS (61%) and CBT (96%) and that of male is larger in MC (63%) and CAR (72%).

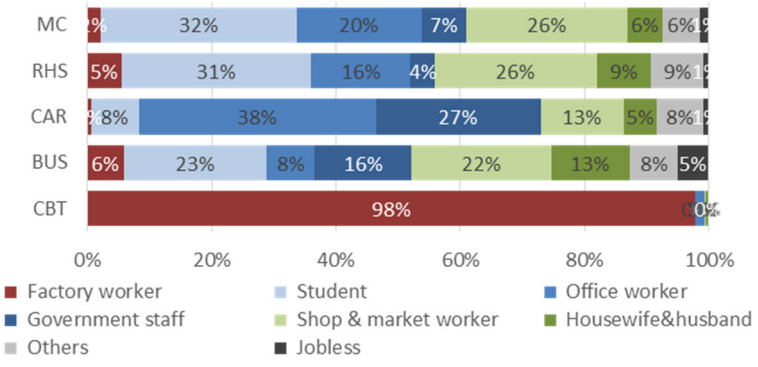


Source: JST

Figure 1.3.39 Age and Sex Distribution by Mode

2) Occupation

Figure 1.3.40 shows the occupation of passengers by mode. MC and RHS have similar composition where student, office worker and shop & market worker share the majority. 65% of CAR users are office worker or government staff. BUS again covers all types of occupation, while CBT is solely used by factory workers.

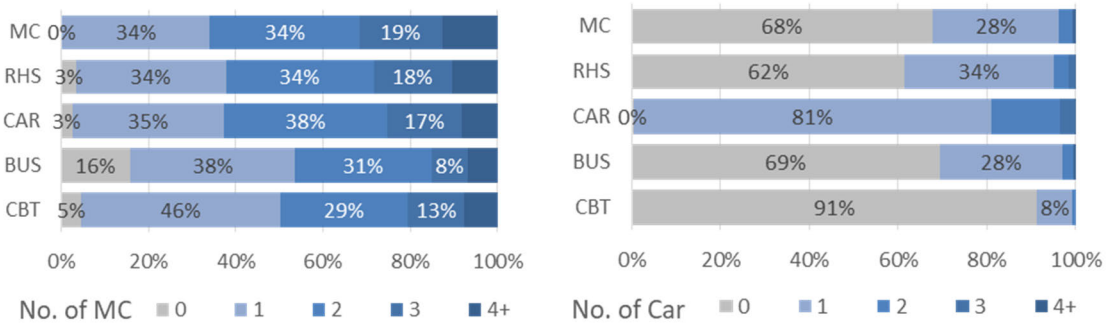


Source: JST

Figure 1.3.40 Occupation by Mode

3) Vehicle Ownership

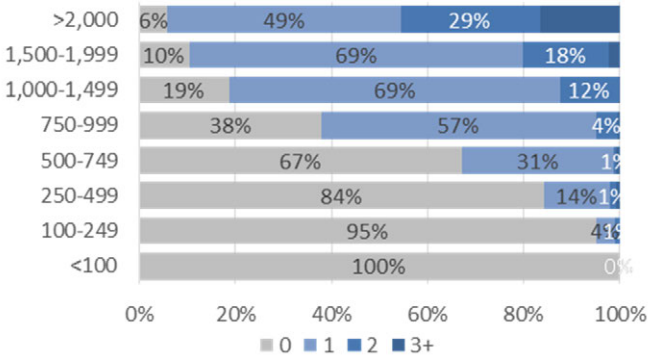
Figure 1.3.41 shows household motorcycle ownership (left) and car ownership (right). The ownership of motorcycle is very similar in all mode users, owning 1~3 motorcycles, except for BUS users. 16% of BUS users have no motorcycle in their household. Regarding car ownership, CAR users have 1 or 2 cars, while 60~70% of MC, RHS and BUS users don't have a car in their household.



Source: JST

Figure 1.3.41 Household Vehicle Ownership by Mode

Figure 1.3.42 shows the car ownership by household monthly income group. It shows the turning point of car ownership is about 500~1,000 USD/month. Since the price of a second-hand car starts from about 6,000 USD and 3~5 years loans are widely available, car ownership is possible for households with less than 1,000 USD/month income if they spent the most part of their income for it.

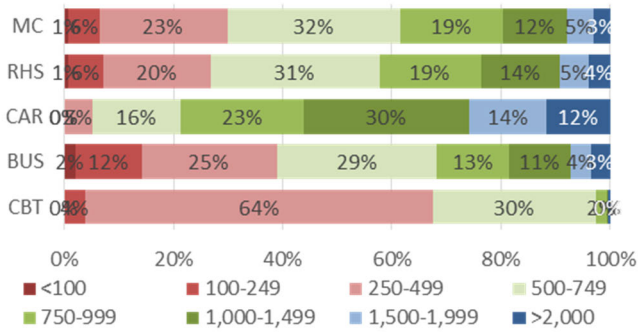


Source: JST

Figure 1.3.42 Car Ownership by Household Monthly Income Group (USD)

4) Household Monthly Income

Figure 1.3.43 shows the household monthly income level of the users of each mode. The ratio of high income households is higher in CAR users while that is lower in CBT users. MC, RHS and BUS are used by passengers in various household income groups.



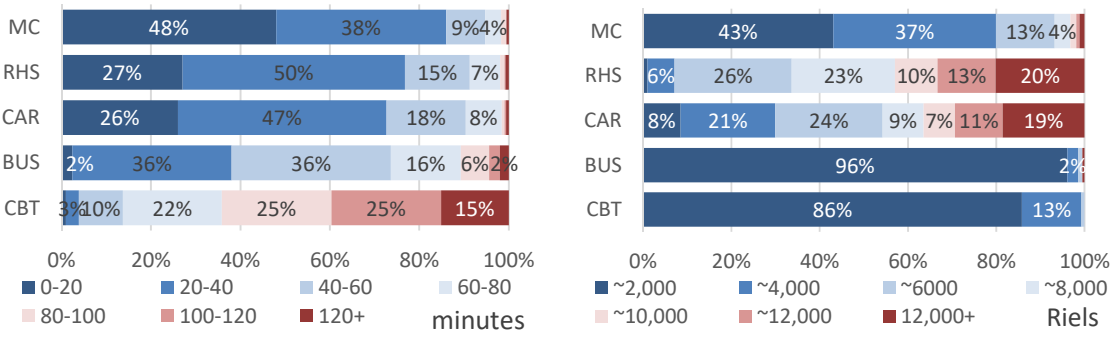
Source: JST

Figure 1.3.43 Household Monthly Income by Mode (USD)

5) Travel Time and Cost

The left side of Figure 1.3.44 shows the travel time of the passengers of each mode. MC tends to be used for short distance trips and BUS and CBT are used for long distance trip. However, this question is highly affected by the location where the surveys for each mode were conducted.

The right side of Figure 1.3.44 shows the travel cost of the passengers of each mode. The fuel cost estimated by the respondents is regarded as travel cost for MC and CAR here. The travel time and cost are similar in RHS and CAR.

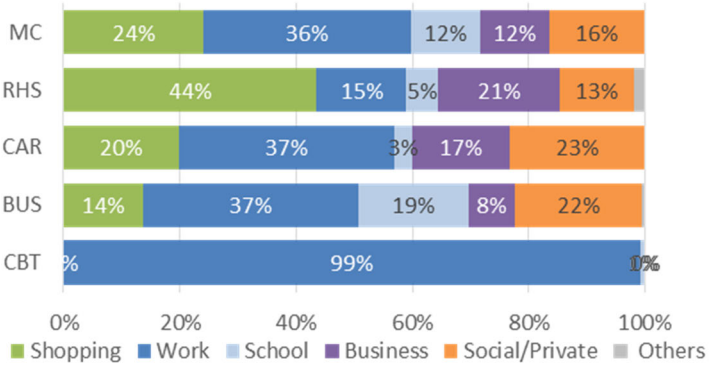


Source: JST

Figure 1.3.44 Travel Time and Cost by Mode

6) Trip Purpose

Figure 1.3.45 shows the trip purpose of the respondents. It has to be noted that there may be a strong bias of survey location because the samples of each mode were collected at different locations.



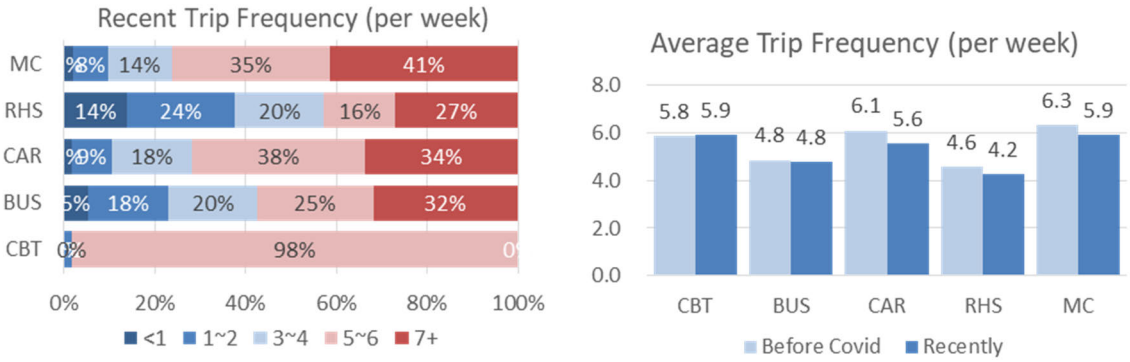
Source: JST

Figure 1.3.45 Trip Purpose by Mode

7) Trip Frequency

The left side of Figure 1.3.46 shows the frequency of the trips which the respondents were making when they were interviewed. About 70% of MC and CAR users answered they make the trip 5 or more times in a week. Contrary, RHS users tended to answer that they use RHS for lower frequency trips.

The right side of Figure 1.3.46 shows the average trip frequency of the trip before and after the COVID-19 pandemic. There was no significant difference between modes.

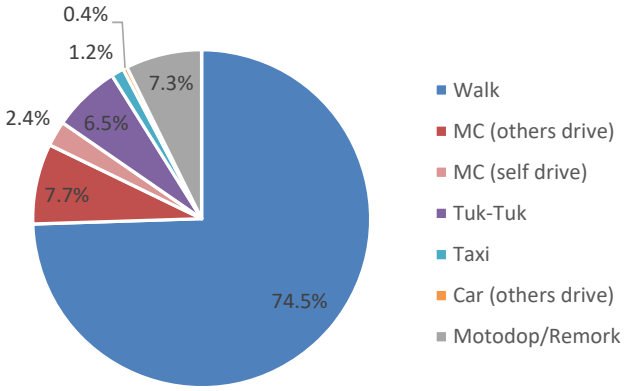


Source: JST

Figure 1.3.46 Trip Frequency by Mode

8) Access/Egress Transport Mode for City Bus

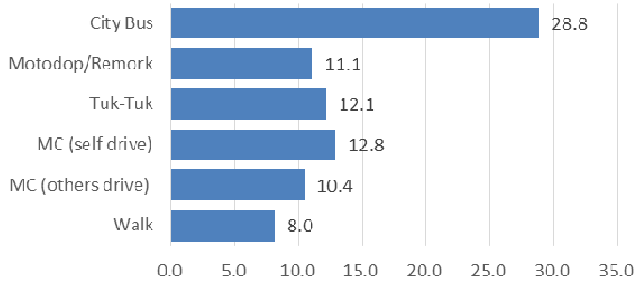
The access/egress transport modes for City Bus answered by respondents are summarised in Figure 1.3.47. About 75% of respondents walk to/from a bus stop while 7.7% of respondents use kiss & ride by motorcycle. The results suggest that improving access to a bus stop will encourage more people to use the City Bus.



Source: JST

Figure 1.3.47 Access/Egress Transport Mode for City Bus

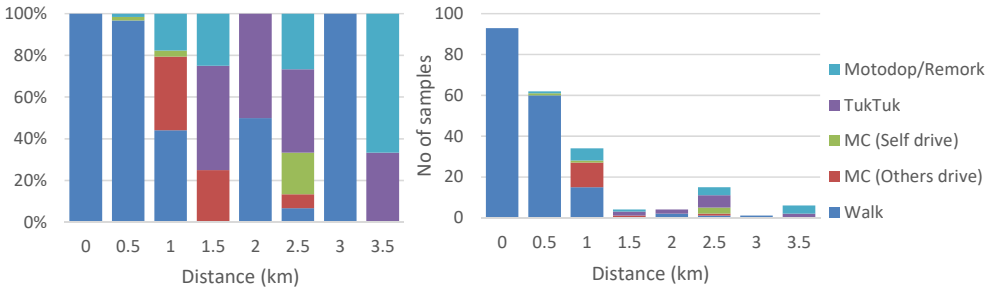
The average travel time of City Bus by respondents is about 29 minutes. City Bus users are likely to spend about 10 minutes for access/egress to a bus stop, which does not vary a lot among modes except for walk.



Note: Time from one point to the next point. Unit: minutes.
Source: JST

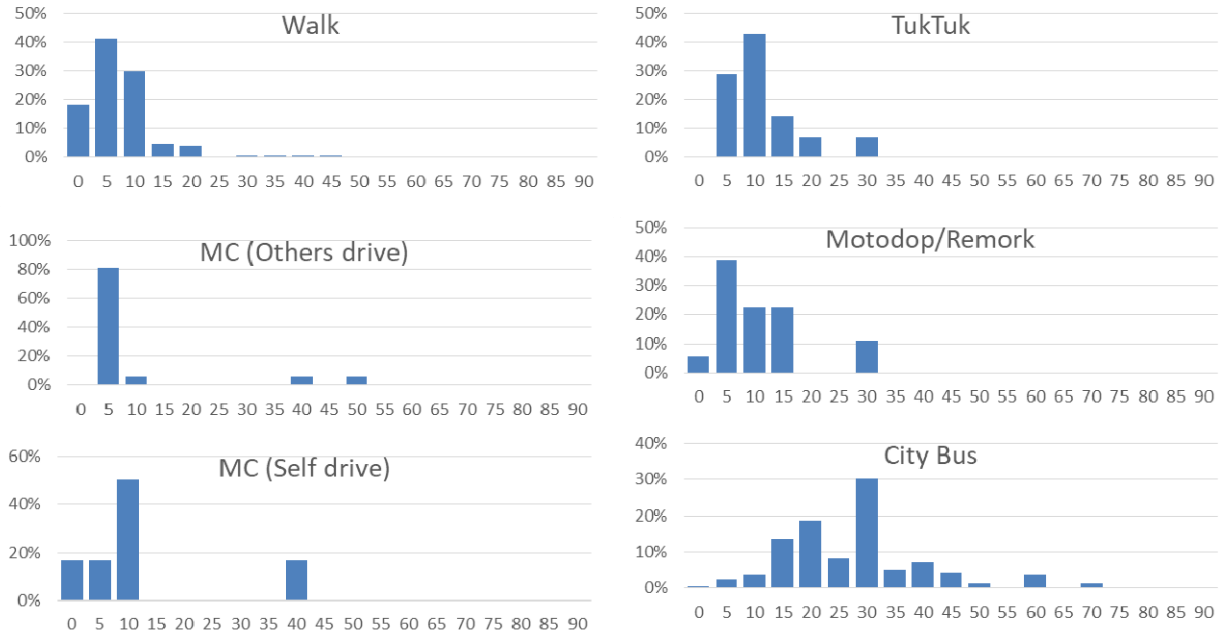
Figure 1.3.48 Average Travel Time of City Bus and the Access/Egress Mode

The distance of access/egress to a bus stop affects the mode choice. As shown in Figure 1.3.49, the shorter the distance is, the more likely City Bus users to choose walk rather than motorized transport. In contrast, the use of motorized transport becomes higher in case of longer distance. Figure 1.3.50 illustrates the distribution of travel time of City Bus and the access/egress modes. City Bus is widely used for 30-minute travel and the travel time of access/egress modes varies around 10 minutes.



Source: JST

Figure 1.3.49 Access/Egress Mode Share by Distance



Note: Time from one point to the next point. Unit: minutes.
Source: JST

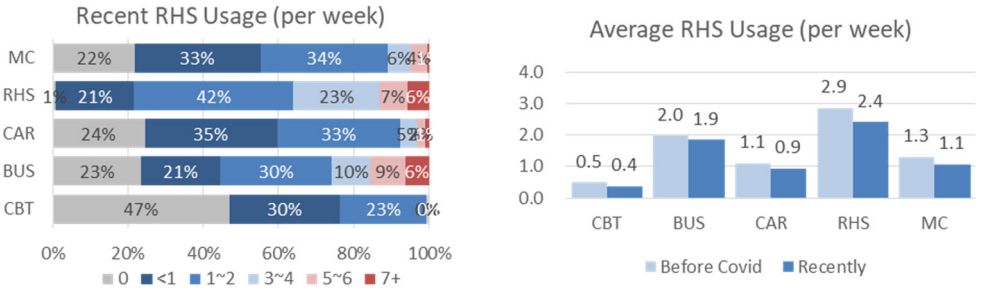
Figure 1.3.50 Travel Time Distribution of City Bus and the Access/Egress Mode

(4) Results of Passenger Interview Survey (Opinion on Transport Situation)

1) Frequency of RHS usage

The left side of Figure 1.3.51 shows the frequency of RHS usage by the users of each mode. More than 75% of respondents answered that they use RHS at least 1 time per week, except for CBT users. Though the usage of RHS is less frequent in CBT users, more than 50% of respondents answered they use RHS at least 1 time per week. This results indicate that RHS has become a very popular transport mode for people in all categories.

The right side of Figure 1.3.51 shows the average number of RHS usage by respondents by each mode.

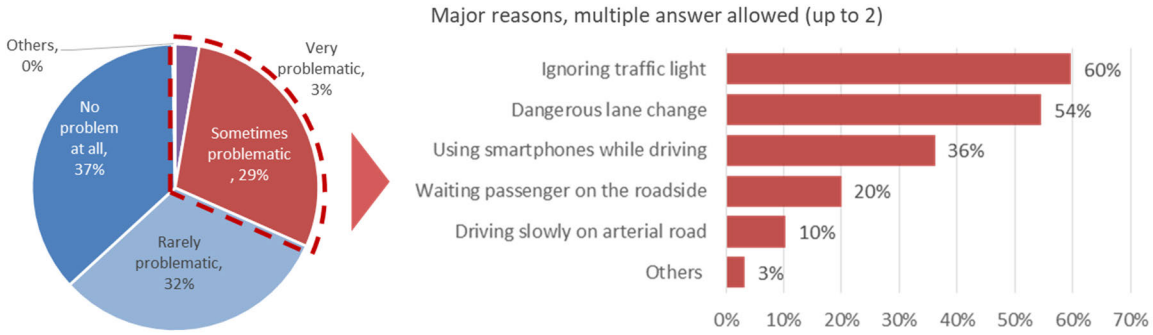


Source: JST

Figure 1.3.51 Frequency of RHS Usage

2) Opinion on Driving Manner of RHS

32% of the respondents answered that the driving manner of RHS is very problematic or sometimes problematic (Figure 1.3.52). The major reasons they answered so were "ignoring traffic light" (60%), "dangerous lane chance" (54%) and "using smartphones while driving" (36%). There was no significant difference among the respondents of each mode.

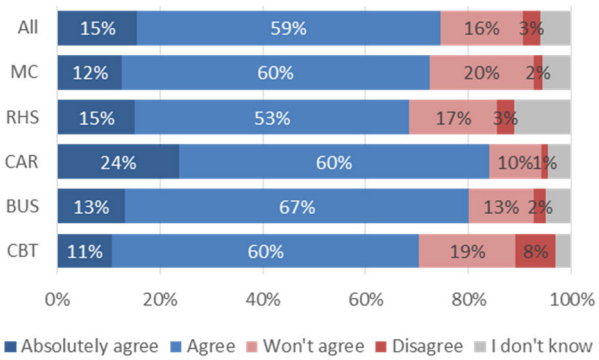


Source: JST

Figure 1.3.52 Opinion on driving manner of RHS

3) Opinion on No Entry Policy of RHS on Arterial Roads

Figure 1.3.53 shows the opinion on no entry policy of RHS on arterial roads. In total, 74% of the respondents answered that they agree to the policy. Especially, CAR users tend to agree to the policy. Even RHS users, 68% of them agreed to the policy.

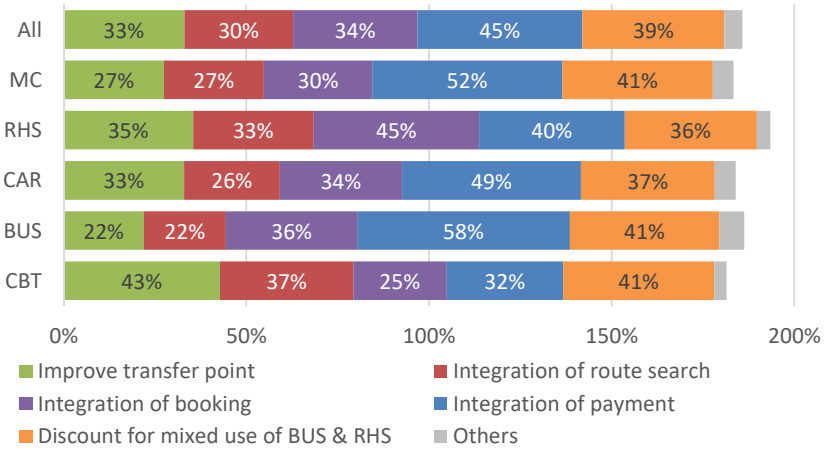


Source: JST

Figure 1.3.53 Opinion on No Entry Policy of RHS on Arterial Roads

4) Important Measures to Realize Integration of City Bus & RHS Service

In the interview survey, integration of City Bus and RHS service was proposed as a possible solution to improve the public transport service. And the important measures to realize it was asked to the respondents. In general, measures related to payment attracts the largest votes (integration of payment 45%, discount for mixed use of BUS & RHS 39%). But, other measures were also regarded as important measures (integration of booking 34%, improve transfer points 33%, integration of route search 30%). The respondents of each mode tended to give importance on different measures.

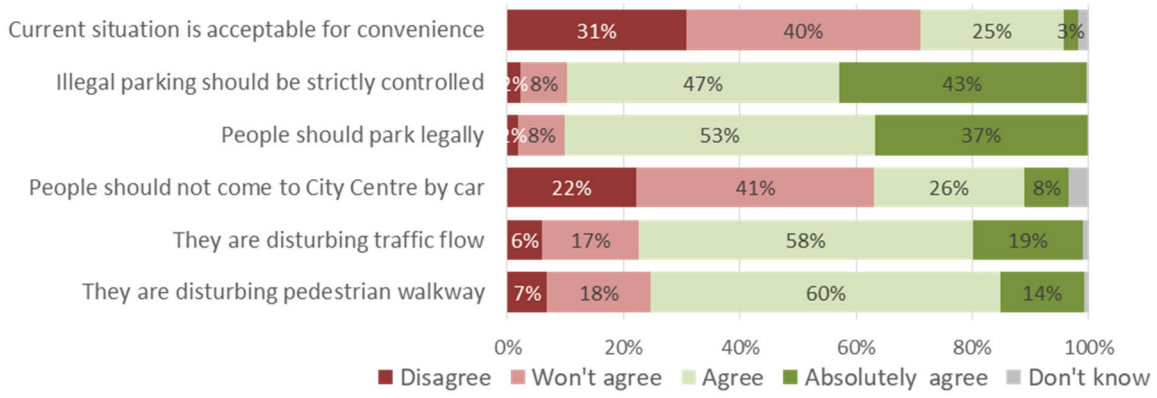


Note: multiple answers allowed up to 2 choices. Therefore, total percentage of share exceeds 100%.
Source: JST

Figure 1.3.54 Important Measures to Realize Integration of City Bus & RHS

5) Opinion on Illegal Roadside Parking

Figure 1.3.55 shows the opinion on illegal roadside parking. 71% of respondents disagree or won't agree to "current situation is acceptable for convenience" and 90% of respondents agree to "illegal parking should be strictly controlled". On the other hand, 63% of respondents disagree or won't agree to "people should not come to city centre by car". The respondents consider the current situation is harmful for both traffic flow and pedestrian environment and agree to the strict control of illegal parking. But they won't agree to force the car users to give up coming to the city centre by car. These results indicate that they want more legal parking space and control of illegal parking.

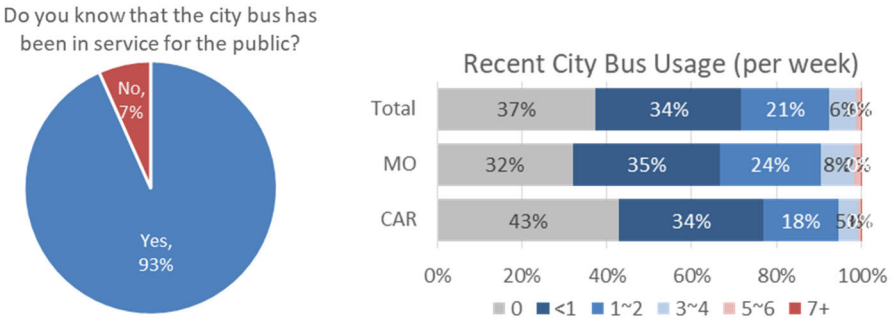


Source: JST

Figure 1.3.55 Opinion on Illegal Roadside Parking

6) Opinion on City Bus (Car and MC Users)

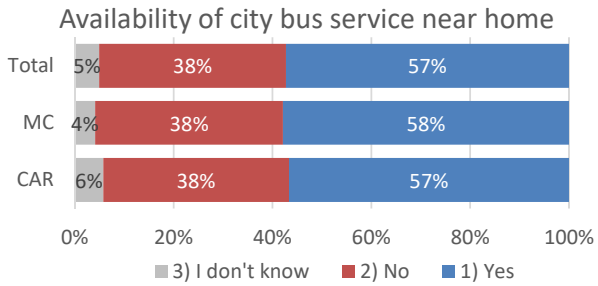
A series of questions were asked to private mode users to understand the opinion on City Bus. Figure 1.3.56 shows 93% of the Car and MC users know that city bus has been in service and 28% of them recently use a city bus at least 1 time per week.



Source: JST

Figure 1.3.56 Recognition and Recent Usage of City Bus (Car and MC Users)

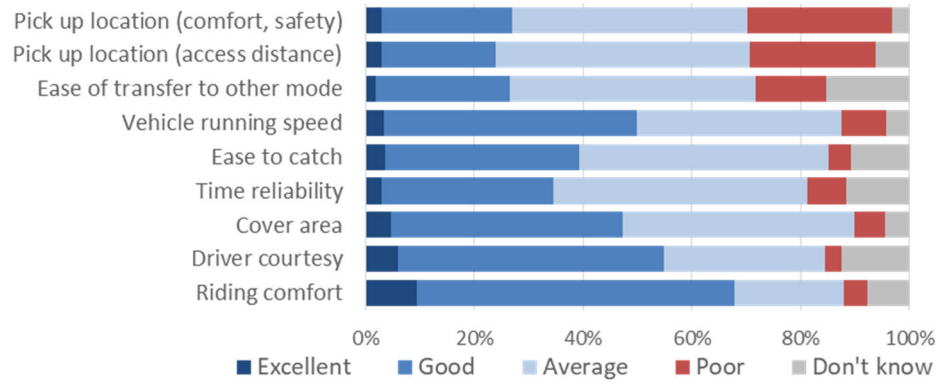
Figure 1.3.57 describes the availability of City Bus service near respondents' homes. More than half CAR and MC users answered that their homes are within the service coverage, while around 5% of all respondents answered that they don't know.



Source: JST

Figure 1.3.57 Availability of City Bus Service near Home (Car and MC Users)

Figure 1.3.58 shows the survey results of how Car and MC users evaluate city bus service. Items about pick up location got the worst score in terms of accessibility, comfortability and safety. 68% of the respondents answered the "Riding comfort" is good or excellent.

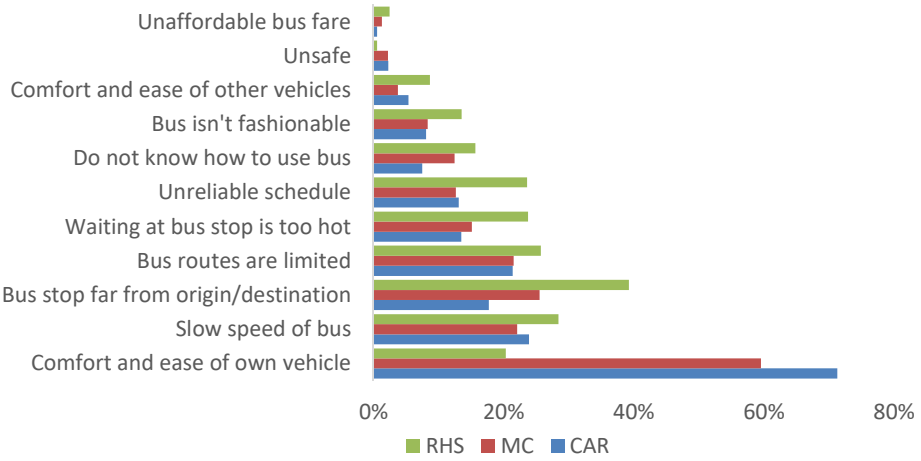


Source: JST

Figure 1.3.58 Evaluation of City Bus service (Car and MC Users)

7) Opinion on City Bus (Car, MC and RHS users)

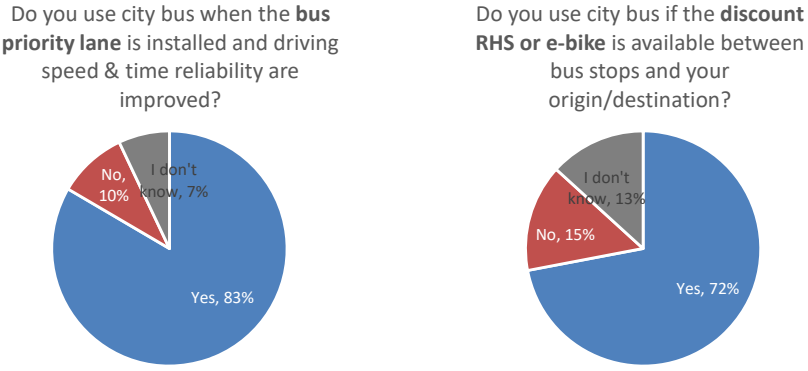
Figure 1.3.59 shows the reasons for not using city bus. The major reasons are "Comfort and ease of own vehicle" both in Car users (71%), MC users (60%) and RHS users (20%) , followed by "Bus stop far from origin/destination", "Slow speed of bus", and "Bus routes are limited".



Note: Multiple answers allowed (up to 2 reasons), Source: JST

Figure 1.3.59 Reason for NOT Using City Bus (Car, MC, RHS Users)

To consider the measures for the modal shift of private mode users to City Bus, willingness of modal shift was asked for two measures (Figure 1.3.60). They might be considered as leading questions in some extent, but 83% of the respondents answered they will use City Bus when the bus priority lane is installed, and 72% of them answered they will use it when the discount RHS or e-bike is available as access/egress mode.

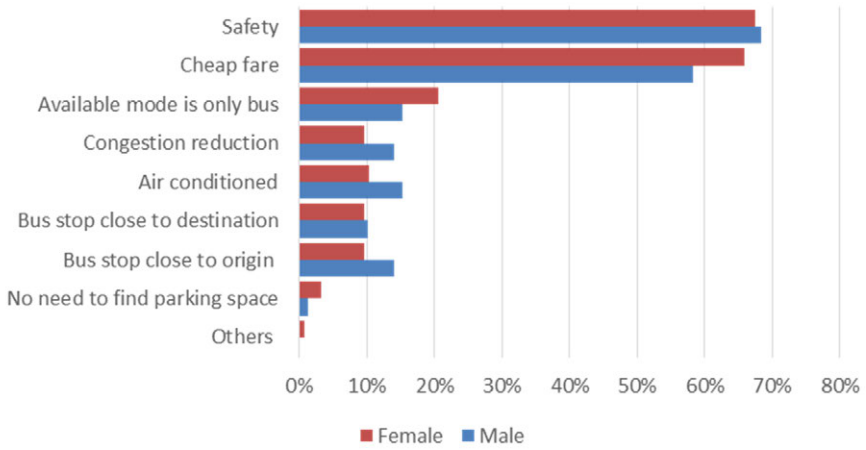


Source: JST

Figure 1.3.60 Willingness to Use City Bus When Measures are Implemented (Car, MC, RHS Users)

8) Opinion on City Bus (City Bus Users)

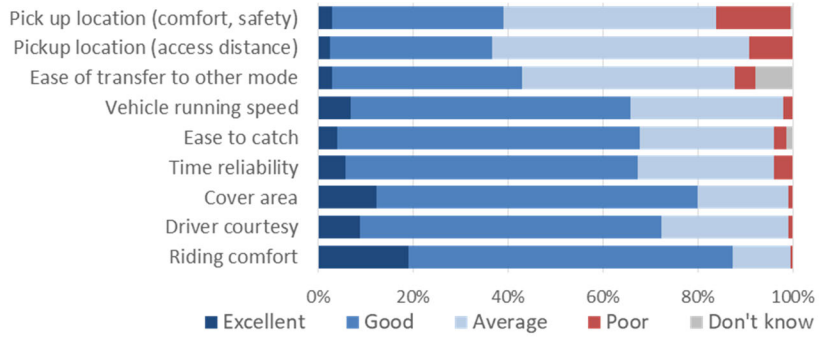
Several questions were asked to City Bus users to understand why they use City Bus and how they evaluate the service. The most common reasons of using city bus are "Safety" and "Cheap fare" which about 60~70% of the respondents selected. In the case of female respondents, "Available mode is only bus" is 20% which is higher than that of male.



Note: Multiple answers allowed (up to 2 reasons)
Source: JST

Figure 1.3.61 Reason for Using City Bus (City Bus Users)

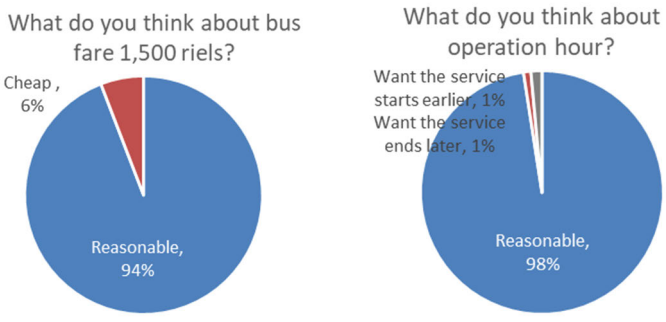
Figure 1.3.62 shows the survey results of how City Bus users evaluate the City Bus service. 16% of the respondents evaluated the comfortability and safety of the pick-up location as "Poor". Compared to the evaluation of non-city bus users in Figure 1.3.58, the evaluation is higher in all items.



Source: JST

Figure 1.3.62 Evaluation of City Bus service (City Bus Users)

In the questionnaire for City Bus users, opinion on the fare level and the operation hour of the City Bus service were included. Regarding fare level, 94% of the respondents answered the current fare level (KHR 1,500) is "Reasonable" and no respondents answered the current fare level is "Expensive". Regarding operation hour, 98% of the respondents answered the current operation hour is "Reasonable".

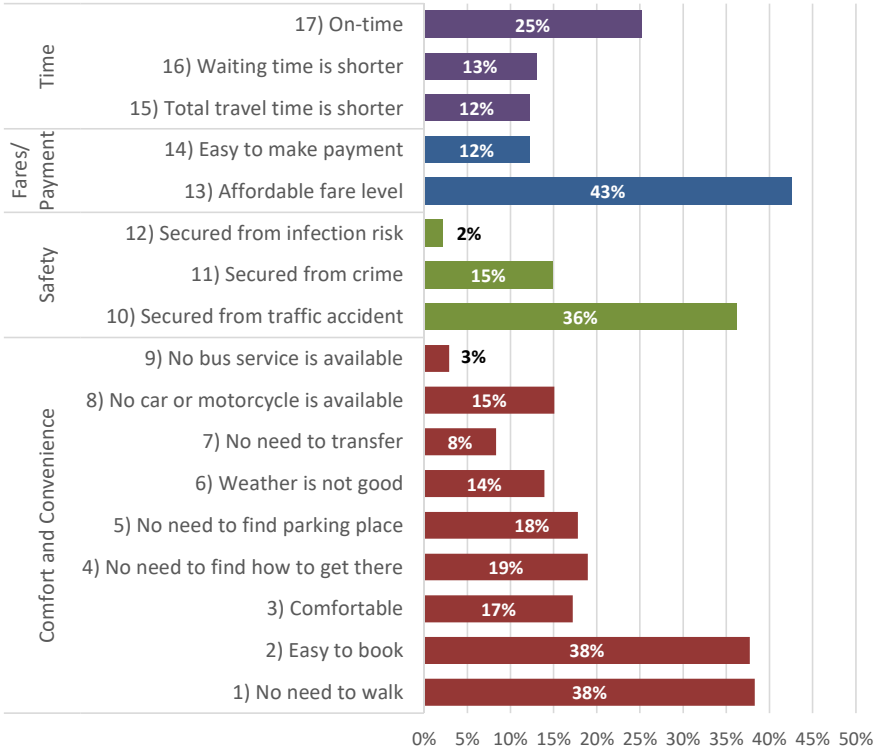


Source: JST

Figure 1.3.63 Opinion on Fare Level and Operation Hour of City Bus (City Bus Users)

9) Opinion on RHS (RHS Users)

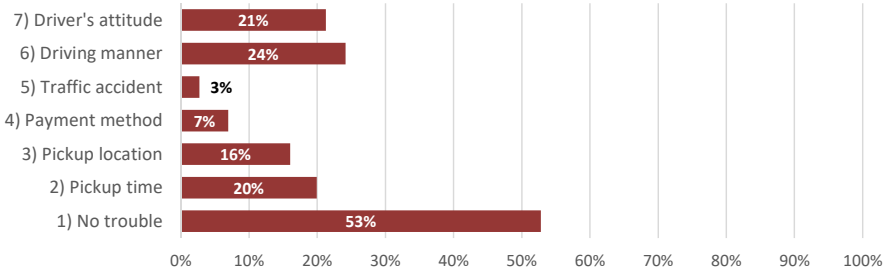
RHS users answered that reasons of using RHS are "Affordable fare level", "No need to walk" and "Easy to book" due to its instant service.



Note: Multiple answers are allowed.
Source: JST

Figure 1.3.64 Reasons to Use RHS (RHS Users)

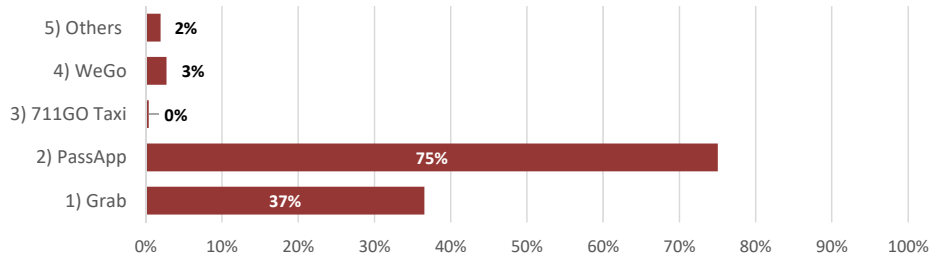
More than half of the RHS users answered that they have no troubles, while some respondents' answers raised a concern of RHS driver's manner, attitude and pickup location.



Note: Multiple answers (up to 2) are allowed.
Source: JST

Figure 1.3.65 Experience of Troubles Using RHS (RHS Users)

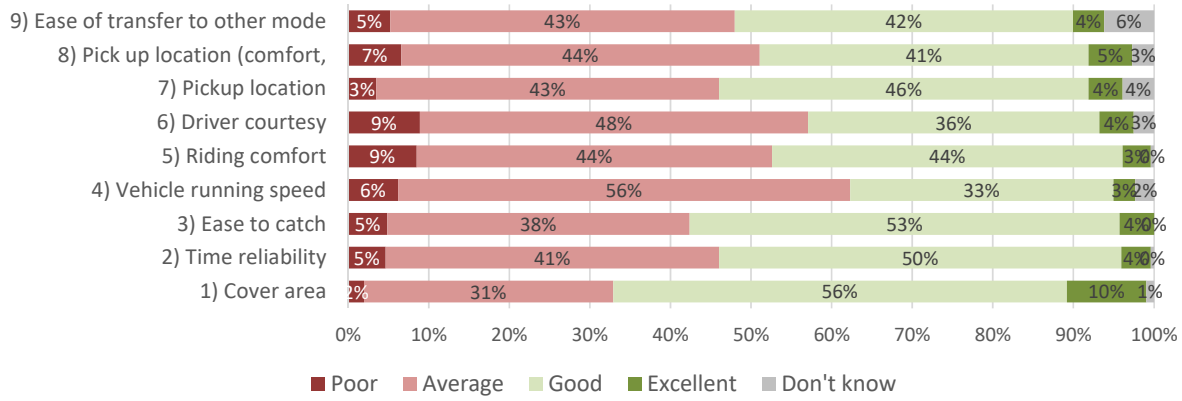
The major RHS apps commonly used in Phnom Penh are PassApp (75%) and Grab (37%).



Note: Multiple answers (up to 2) are allowed.
Source: JST

Figure 1.3.66 RHS App Recently Used (RHS Users)

RHS users are generally satisfied with the coverage and the convenience of RHS, while they are more likely concerned about the driver's driving speed and their attitude.

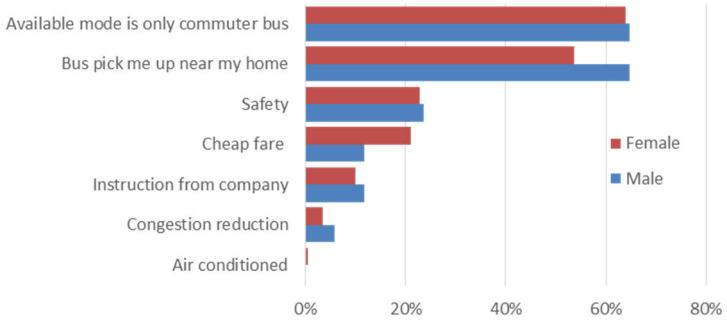


Source: JST

Figure 1.3.67 Evaluation of RHS (RHS Users)

10) Opinion on Commuter Bus (Commuter Bus Users)

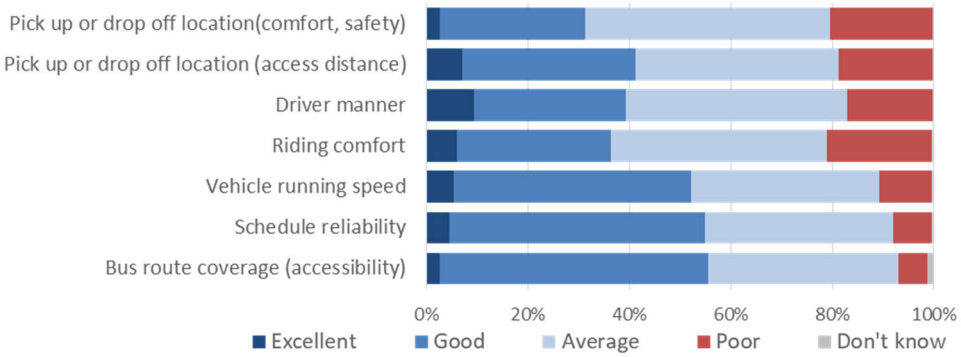
Figure 1.3.68 shows the reason why the Commuter Bus passengers use it. The two major reasons which about 60% of the respondents answered were "Available mode is only commuter bus" and "Bus pick me up near my home". Considering 96% of the commuter bus passengers are female and most of the commuter buses are pickup or truck without seat, the results show the current severe situation of factory workers.



Note: Multiple answers allowed (up to 2 reasons)
Source: JST

Figure 1.3.68 Reason for Using Commuter Bus

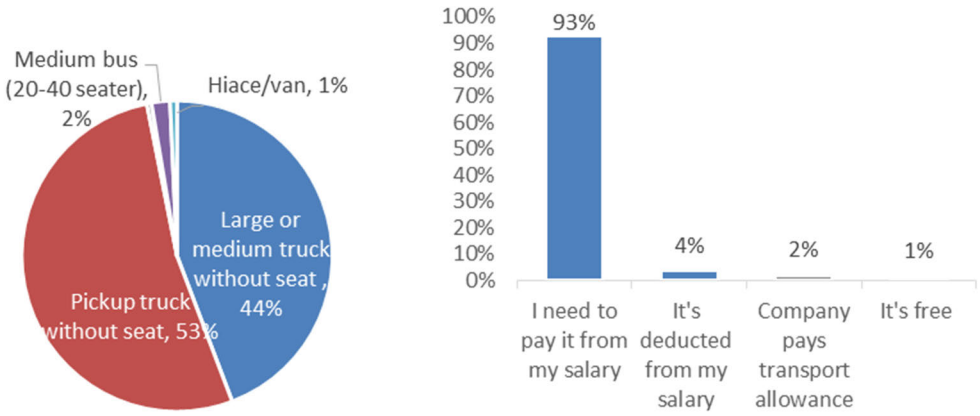
Figure 1.3.69 shows the survey results of how commuter bus users evaluate the commuter bus service. In general, commuter bus got a lower rating than city bus (Figure 1.3.62). About 20% of the respondents evaluated 4 items as “Poor”.



Source: JST

Figure 1.3.69 Evaluation of Commuter Bus Service

The left side of Figure 1.3.70 shows the vehicle type of the commuter bus which respondents use. 97% of the respondents answered that they use large, medium or pickup truck without seat. Besides, 93% of the respondents pay the fare from their salary.



Source: JST

Figure 1.3.70 Vehicle Type (left) and Payer (right) of Commuter Bus

1.3.5 Roadside Traffic Survey (RTS)

(1) Outline

The purpose of the roadside traffic count survey is to identify the present conditions of traffic on the congested roads sections.

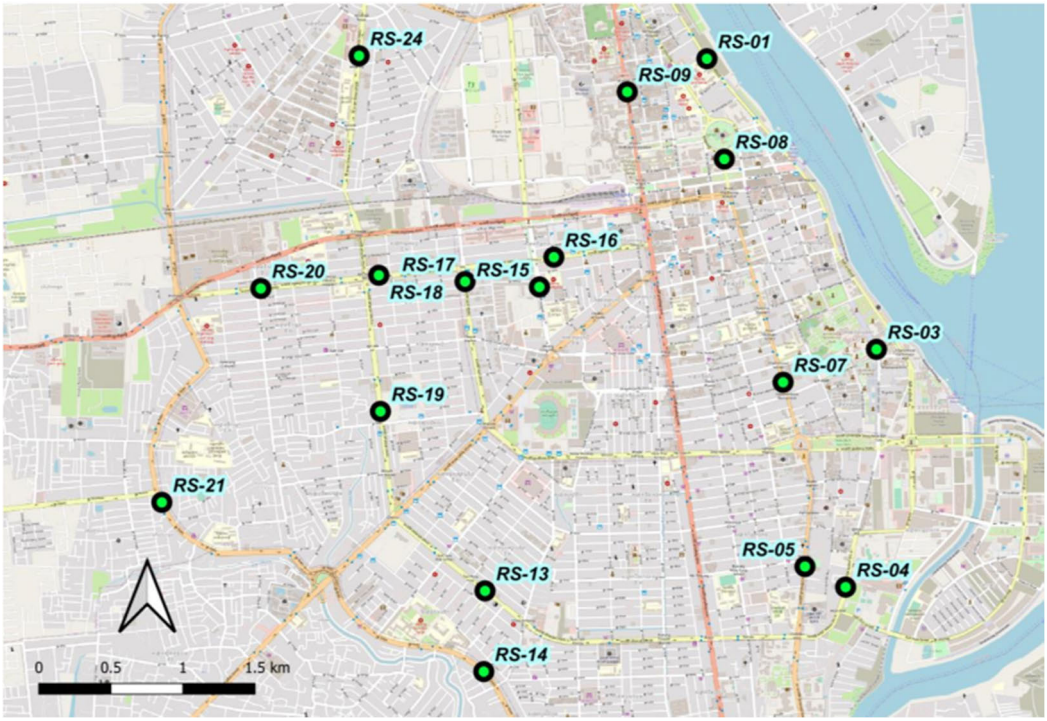
(2) Survey Coverage

- The survey was conducted at 17 locations in Phnom Penh (see Table 13.2-10 and Figure 13.2-13).
- The classified vehicular count was conducted on both sides of the traffic directions. The survey must be conducted during the weekday (from Tuesday through Thursday excluding Saturday, Sunday, and public holiday), which the duration is 24 hours from 6:00 to 6:00 for 6 locations and for 16 hours from 6:00 to 22:00 at 11 locations.
- Vehicular classification is the same as other traffic count surveys.

Table 1.3.18 Roadside Traffic Count Survey Stations

Survey Location ID	Road Name	Survey Duration (Hours)	Remark
RS-1	Sisowat Blvd.	**24**	City Centre
RS-3	Sothearos (Rd. 3)	**24**	City Centre
RS-4	Sothearos (Rd. 3)	16	City Centre
RS-5	Norodom Blvd. (Rd. 41)	16	City Centre
RS-7	Norodom Blvd. (Rd. 41)	**24**	City Centre
RS-8	Norodom Blvd. (Rd. 41)	16	City Centre
RS-9	Norodom Blvd. (Rd. 93)	**24**	City Centre
RS-13	Mao Tse Toung Blvd. (Rd. 245)	16	City Centre
RS-14	Road 271	16	City Centre
RS-15	Road Chekoslovaki (Rd. 169)	16	City Centre
RS-16	Kampuchea Krom Blvd. (Rd. 128)	16	City Centre
RS-17	Nerhu (Rd. 125)	**24**	City Centre
RS-18	Kampuchea Krom Blvd. (Rd. 128)	16	City Centre
RS-19	Mao Tse Toung Blvd. (Rd. 245)	**24**	City Centre
RS-20	Kampuchea Krom Blvd. (Rd. 128)	16	City Centre
RS-21	Road 271	16	City Centre
RS-24	Road 289	16	City Centre

Source: JST



Source: JST

Figure 1.3.71 Roadside Traffic Count Survey Locations (City Centre)

(3) Survey Results

1) Summary of Roadside Traffic Count Results

Table 1.3.19 shows the summary of the Roadside Traffic Count Survey results.

Compared to the results in 2012, traffic volume has increased at the boundary of CBD, RS-14, RS-21 (Road 271) and RS-1 (Sisowat Blvd.). Also, the volume has increased in front of AEON 1, RS-4 (Sothearos (Rd.3)). Contrarily, the volume has decreased near the new flyover, Techno Sky Bridge, at RS-18 (Kampuchea Krom Blvd. (Rd. 128)) and RS-19 (Mao Tse Toung Blvd. (Rd. 245)). Peak ratio at screen lines varies between 7% and 10%. It should be noted that the modal share of three wheeler is low at Norodom Blvd. (RS-5 and 7) since three wheeler is banned to go through the road.

Table 1.3.19 Summary of Roadside Traffic Count Results

ID	Road Name	Traffic Volume in 2012 (PCU/24hr)	Traffic Volume in 2022* (PCU/24hr)	Peak Ratio ** (PCU basis)	Ratio of Daily Traffic *** (PCU basis)	Motorbike Ratio (veh basis)	3-Wheeler Ratio **** (veh basis)	Sedan Ratio (veh basis)
RS-1	Sisowat Blvd.	32,138	40,018	10%	1.36	67%	14%	14%
RS-3	Sothearos (Rd. 3)*****	N/A	16,044	8%	1.57	71%	16%	11%
RS-4	Sothearos (Rd. 3)	27,387	38,720	7%	1.57	65%	17%	13%
RS-5	Norodom Blvd. (Rd. 41)	37,910	49,487	8%	1.48	64%	11%	20%
RS-7	Norodom Blvd. (Rd. 41)	42,549	43,686	9%	1.50	65%	5%	26%
RS-8	Norodom Blvd. (Rd. 41)	27,550	26,444	8%	1.49	68%	8%	19%
RS-9	Norodom Blvd. (Rd. 93)	66,374	65,901	8%	1.40	62%	15%	16%
RS-13	Mao Tse Toung Blvd. (Rd. 245)	44,831	44,535	8%	1.47	67%	13%	15%
RS-14	Road 271	49,351	71,109	7%	1.50	72%	11%	12%

ID	Road Name	Traffic Volume in 2012 (PCU/24hr)	Traffic Volume in 2022* (PCU/24hr)	Peak Ratio ** (PCU basis)	Ratio of Daily Traffic *** (PCU basis)	Motorbike Ratio (veh basis)	3-Wheeler Ratio **** (veh basis)	Sedan Ratio (veh basis)
RS-15	Road Chekoslovaki (Rd. 169)	40,795	43,565	7%	1.46	70%	11%	14%
RS-16	Kampuchea Krom Blvd. (Rd. 128)	33,186	31,316	8%	1.45	62%	16%	17%
RS-17	Nerhu (Rd. 125)	33,100	33,958	8%	1.31	63%	14%	17%
RS-18	Kampuchea Krom Blvd. (Rd. 128)	40,734	34,864	7%	1.49	64%	12%	19%
RS-19	Mao Tse Toung Blvd. (Rd. 245)	52,822	48,036	7%	1.38	69%	10%	16%
RS-20	Kampuchea Krom Blvd. (Rd. 128)	32,910	37,844	8%	1.49	69%	10%	16%
RS-21	Road 271	53,303	66,595	7%	1.51	66%	13%	14%
RS-24	Road 289	34,417	38,350	8%	1.49	62%	10%	23%

*16 hours traffic volume is converted into the 24 hours traffic volume based on the survey result of the 24 hours traffic count survey.

** Peak rate is ratio for 24 hours.

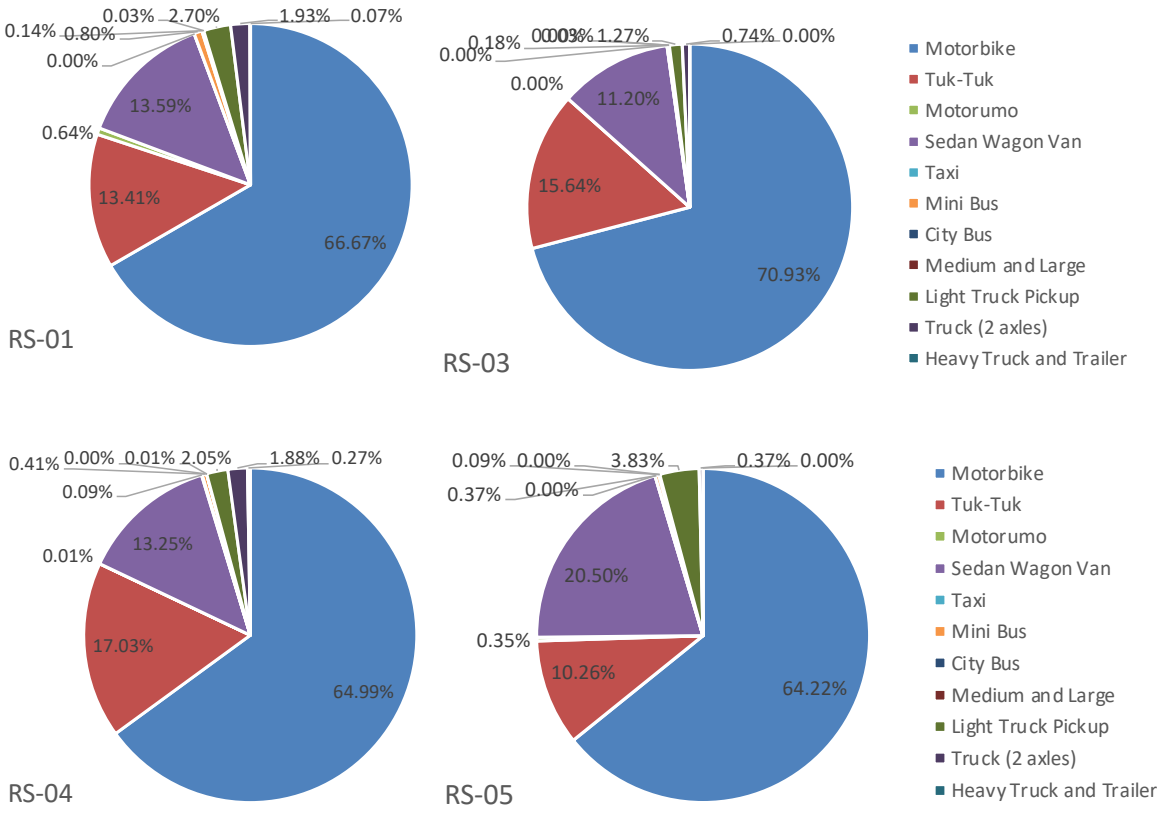
*** Ratio of daily traffic is 24-hour traffic / 12-hour traffic.

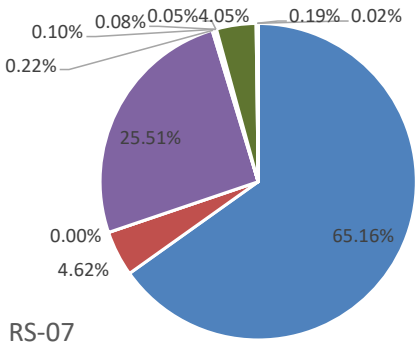
**** 3-wheeler includes tuk-tuk and motorumo.

***** RS-3's location has been changed in 2022 due to the road restrictions around the royal palace.

2) Composition of Vehicle Type by Survey Location

Figure 1.3.72 shows the composition of vehicle type by survey location. As shown, motorbike is the dominant vehicle type. In general, ratio of sedan, wagon and van is higher at RS-5, RS-7 and RS-27, over 20% of total traffic volume. The percentage of tuk-tuk is about 10~17% at all locations.





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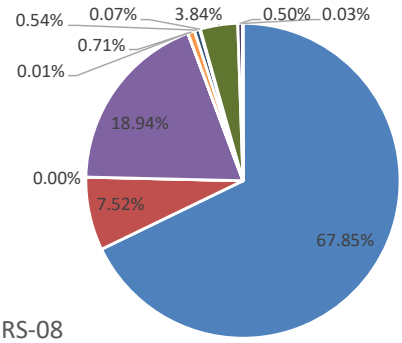

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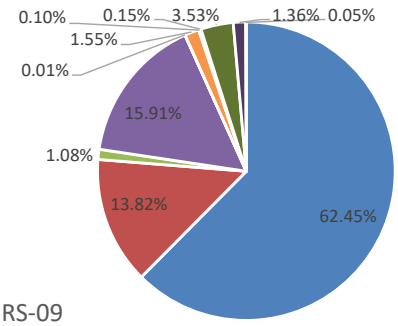

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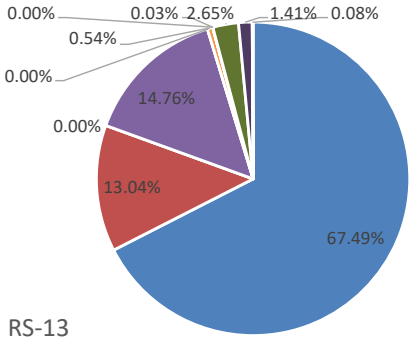

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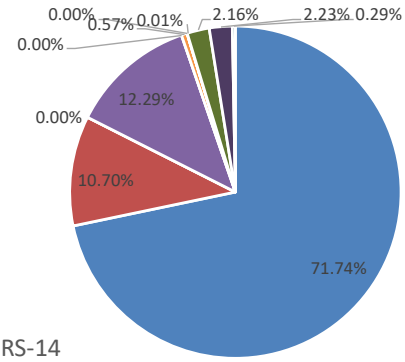

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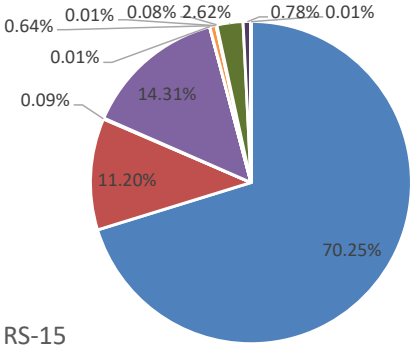

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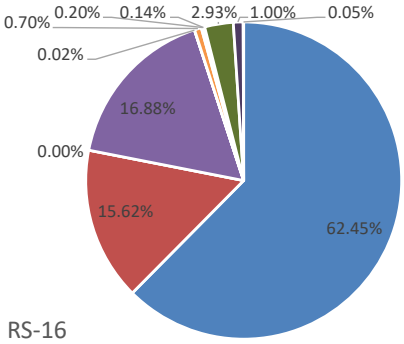

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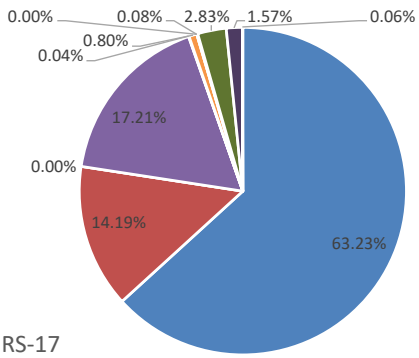

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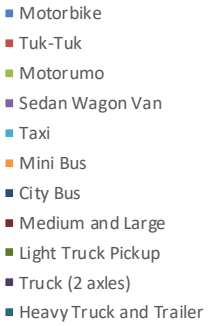
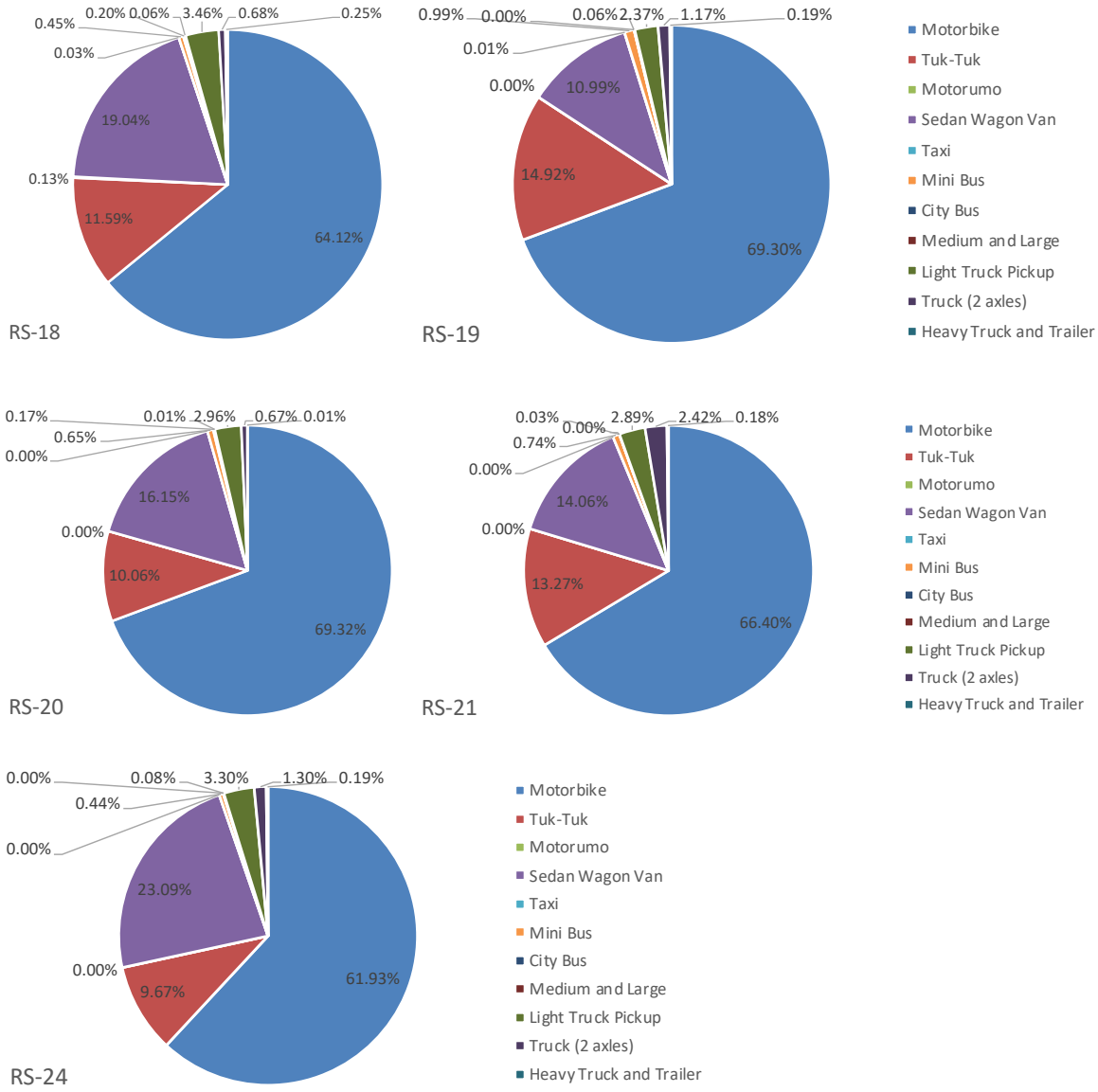


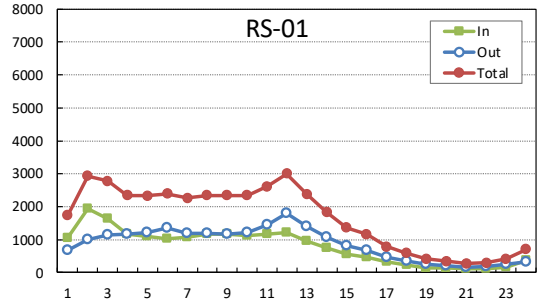


Source: JST

Figure 1.3.72 Composition of Vehicles by Station (Vehicle Base)

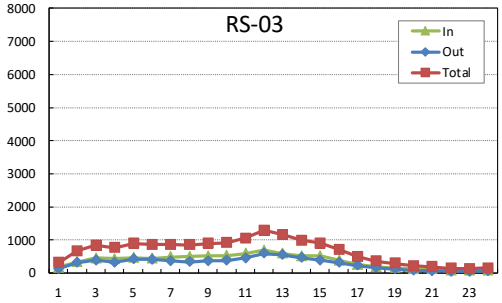
3) Hourly Fluctuation by Survey Location

Figure 1.3.73 shows the hourly fluctuation of traffic volume at each survey location. In total, the peak ratio for the morning peak was 7.1% between 8:00~9:00 and for the evening peak was 8.3% between 17:00~18:00.



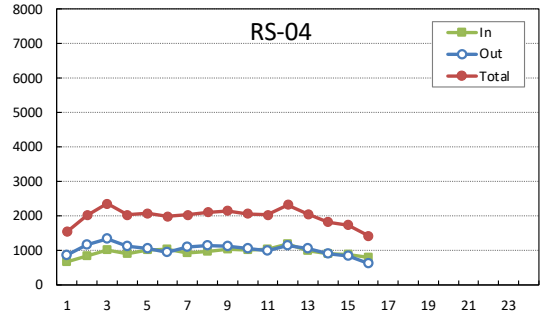
IN: Chroy Changvar Bridge to Wat Phnom

OUT: Wat Phnom to Chroy Changvar Bridge



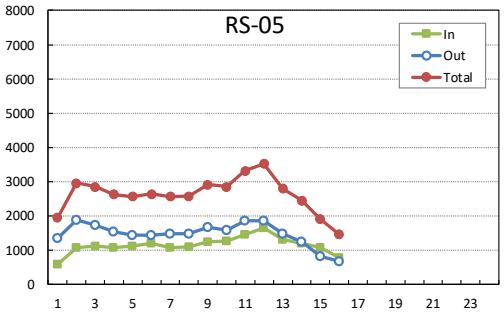
IN: Independence monument to Royal Palace

OUT: Royal Palace to Independence monument



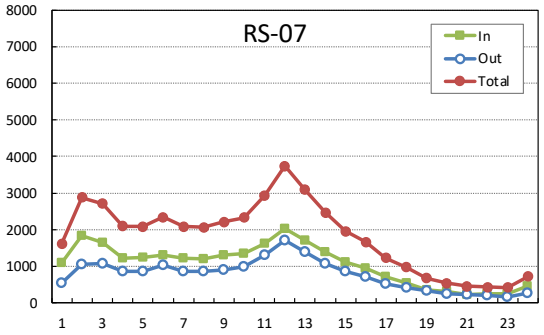
IN: Independence monument to Preah Norodom Blvd.

OUT: Preah Norodom Blvd. to Independence monument



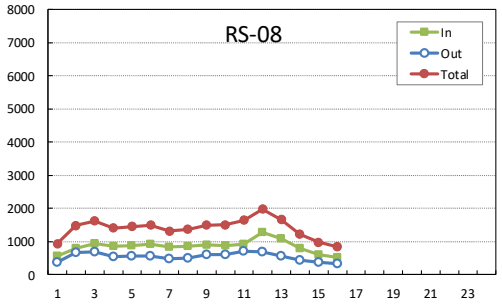
IN: Independence monument to Kbal Thnal Flyover

OUT: Kbal Thnal Flyover to Independence monument



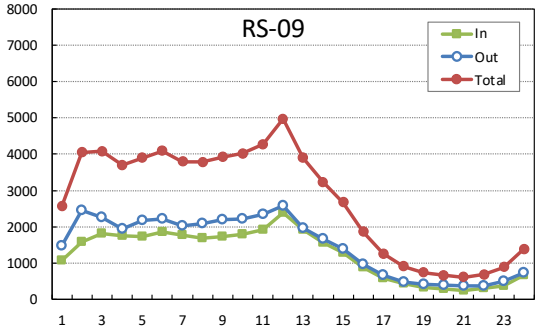
IN: Independence monument to Wat Phnom

OUT: Wat Phnom to Independence monument



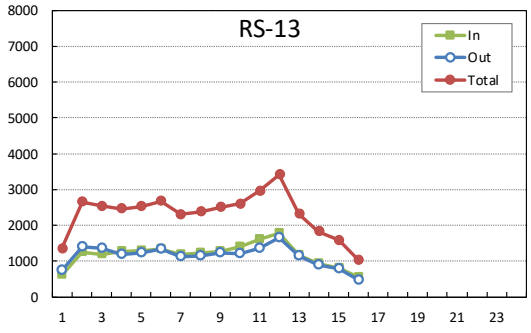
IN: Independence monument to Wat Phnom

OUT: Wat Phnom to Independence monument



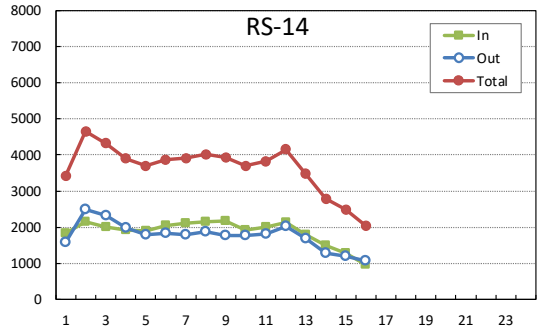
IN: Central market to Chroy Changvar roundabout

OUT: Chroy Changvar roundabout to Central market



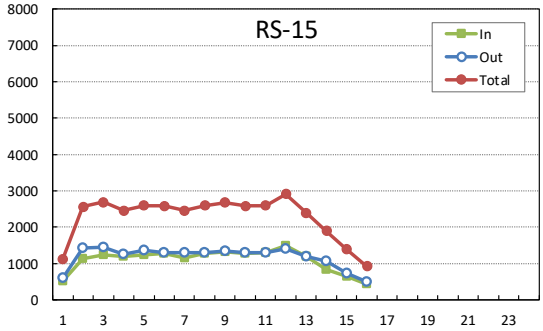
IN: Tuol Tom Poung market to Deum Kor market

OUT: Deum Kor market to Tuol Tom Poung market



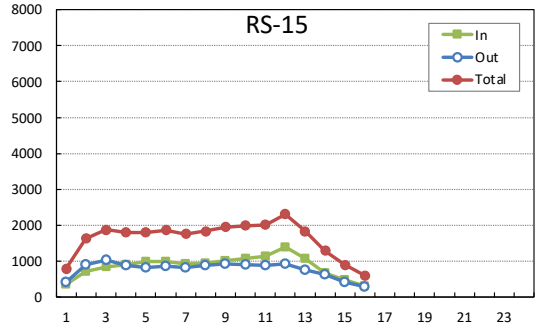
IN: Stoeng Meanchey Flyover to Kbal Thnal Flyover

OUT: Kbal Thnal Flyover to Stoeng Meanchey Flyover



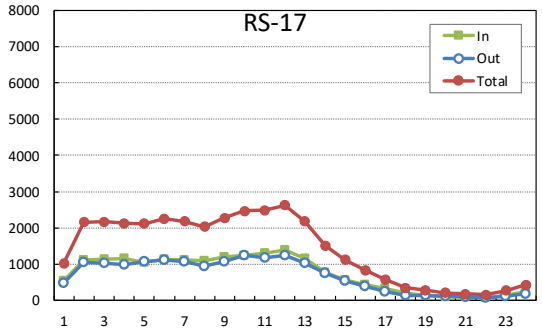
IN: Olympic stadium to Two Pears intersection

OUT: Two Pears intersection to Olympic stadium



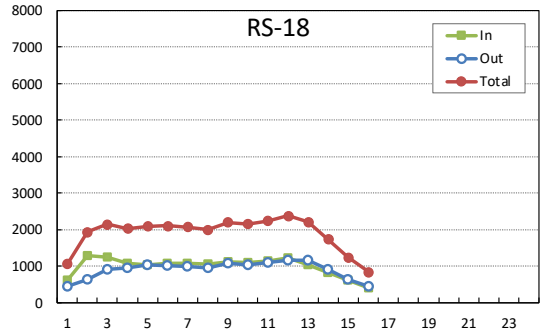
IN: Central market to 7 Makara Flyover

OUT: 7 Makara Flyover to Central market



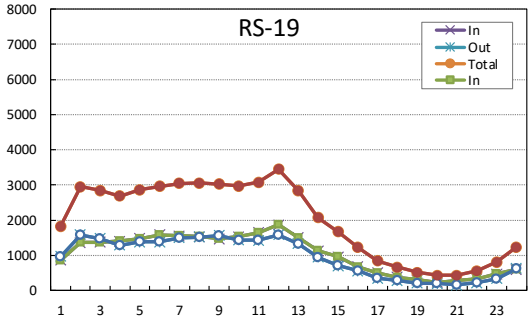
IN: Olympic stadium to Ministry of National Defence

OUT: Ministry of National Defence to Olympic stadium



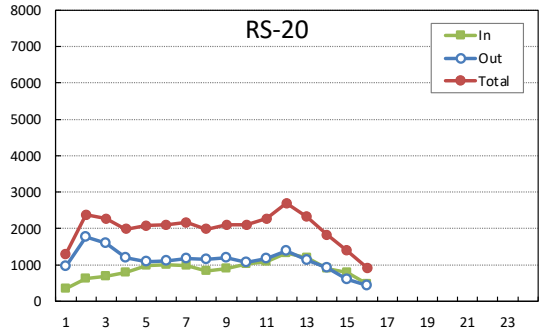
IN: Central market to 7 Makara Flyover

OUT: 7 Makara Flyover to Central market



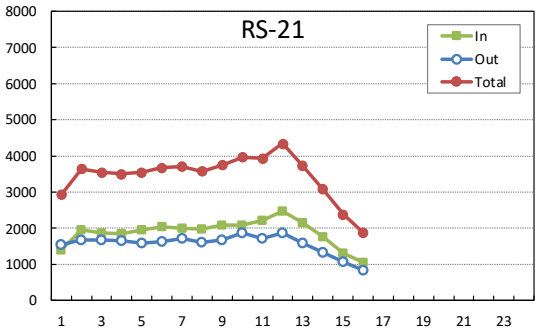
IN: 5 Makara Flyover to Deum Kor market

OUT: Deum Kor market to 5 Makara Flyover



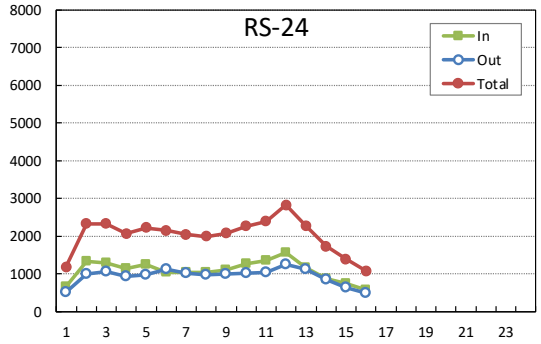
IN: : Central market to 7 Makara Flyover

OUT: 7 Makara Flyover to Central market



IN: Stoeng Meanchey Flyover to 7 Maraka Flyover

OUT: 7 Makara Flyover to Stoeng Meanchey Flyover



IN: Tuol Kork Antenna to Tuol Kork roundabout

OUT: Tuol Kork roundabout to Tuol Kork Antenna

Unit: PCU/hour
Source: JST

Figure 1.3.73 Hourly Fluctuation by Survey Location

1.3.6 Intersection Traffic Survey (ITS)

(1) Outline

The Intersection Traffic Count Survey aims to identify the present conditions of the traffic at congested intersections.

Table 1.3.20 Outline of Intersection Traffic Survey

Location	• 13 intersections on arterial roads
Survey duration	• 16 hours (06:00-22:00) on a weekday from Tuesday to Thursday (excluding Saturday, Sunday and public holidays)

Source: JST

(2) Survey Coverage

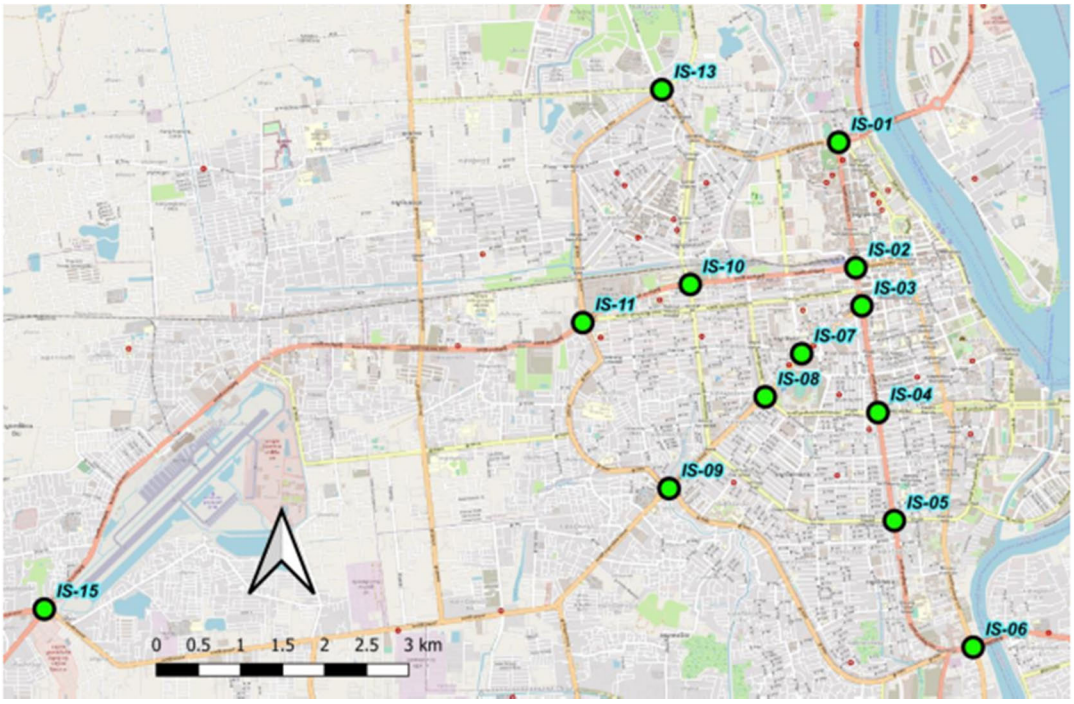
The Intersection Traffic Survey was conducted at 13 locations in Phnom Penh.

Table 1.3.21 Locations of Intersection Traffic Survey

Location	Type (Structure)	Road Name	Traffic Count
IS-01	Roundabout	Oknha Kleang Moeung St and Monivong (before Chruoy Chongvar Bridge)	16 hours
IS-02	Junction	Russian Blvd. and Monivong	16 hours
IS-03	Junction	Monivong and Charles de Gaulle (217)	16 hours
IS-04	Junction	Shihanouk and Monivong	16 hours
IS-05	Junction	Monivong and Mao Tse Toung	16 hours
IS-06	Flyover	Monivong and Norodom (before Monivong Bridge)	16 hours
IS-07	Junction (5 legs)	182 and Charles de Gaulle (217)	16 hours
IS-08	Junction	Shihanouk and Monireth (217)	16 hours
IS-09	Flyover	Inner Ring Road and Monireth (217)	16 hours
IS-10	Flyover (Techno Sky Bridge)	2 Russian Blvd. and 289	16 hours
IS-11	Flyover	Russian Blvd., Inner Ring Rd. and 265	16 hours

Location	Type (Structure)	Road Name	Traffic Count
IS-13	Roundabout	St. 355 and St. 598	16 hours
IS-15	Grade separation (under construction)	NR3, NR4, Russian and Veng Sreng Rd.	16 hours

Note: The intersection structures at IS-06, IS-09, IS-10 and IS-15 have changed from 2012.
Note: IS-15 was under construction of grade separation when the survey was conducted.
Source: JST



Source: JST

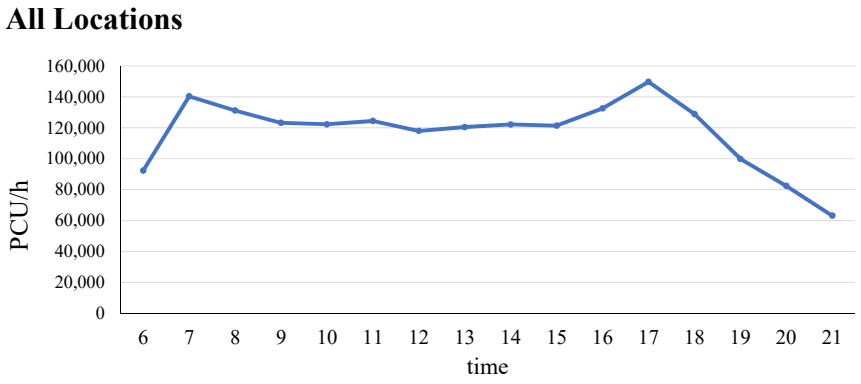
Figure 1.3.74 Locations of Intersection Traffic Survey

A classified vehicular count was conducted at each direction of traffic flow at intersections. The survey was conducted during the weekday (from Tuesday through Thursday excluding Saturday, Sunday, and public holiday). The duration of traffic count is 16 hours from 6:00 to 22:00. The vehicle type was counted separately at every 15-minutes interval. The vehicle classification follows Table 1.3.8.

(3) Results of Intersection Traffic Survey

1) All Locations

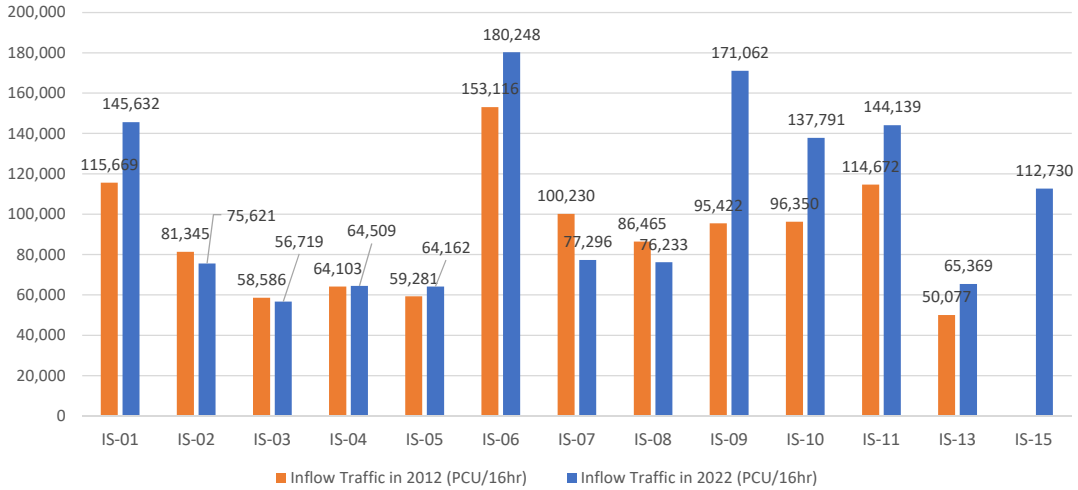
Peak hours of traffic in CBD can be observed at 7:00 in the morning, at 11:00 during lunch breaks, and at 17:00 when returning home. Especially at 17:00, the traffic volume is the highest and it becomes a heavy traffic jam. Therefore, from the aspect of traffic management, it is recommended to manage demand for commuting to work or school, say, as a shift to public transport from private traffic.



Source: JST

Figure 1.3.75 Traffic Volume of All Locations

Comparison of the traffic volume at intersections between 2012 and 2022 such as IS-2, IS-3, IS-4, IS-7, and IS-8 (St.271: inside the Inner Ring Road) in the city centre is flat or in a downward trend. On the other hand, an increasing trend is seen at major intersections such as IS-01, IS-06, IS-09, IS-11, and IS-13 on the fringe of the CBD. This clearly shows the sprawl of recent years. In suburban areas where traffic volume is increasing, traffic management such as construction of new signalized intersections and connection of existing signals to the traffic control system is necessary.



Note: Survey was not conducted at IS-15 in 2012.
Source: JST

Figure 1.3.76 Comparison of Inflow Traffic at Intersections (2012 and 2022)

Table 1.3.22 Comparison of Inflow Traffic at Intersections (2012 and 2022)

	Inflow Traffic in 2022	Inflow Traffic in 2012	AAGR (%)
IS-01	145,632	115,669	2.33%
IS-02	75,621	81,345	-0.73%
IS-03	56,719	58,586	-0.32%
IS-04	64,509	64,103	0.06%
IS-05	64,162	59,281	0.79%
IS-06	180,248	153,116	1.64%
IS-07	77,296	100,230	-2.56%

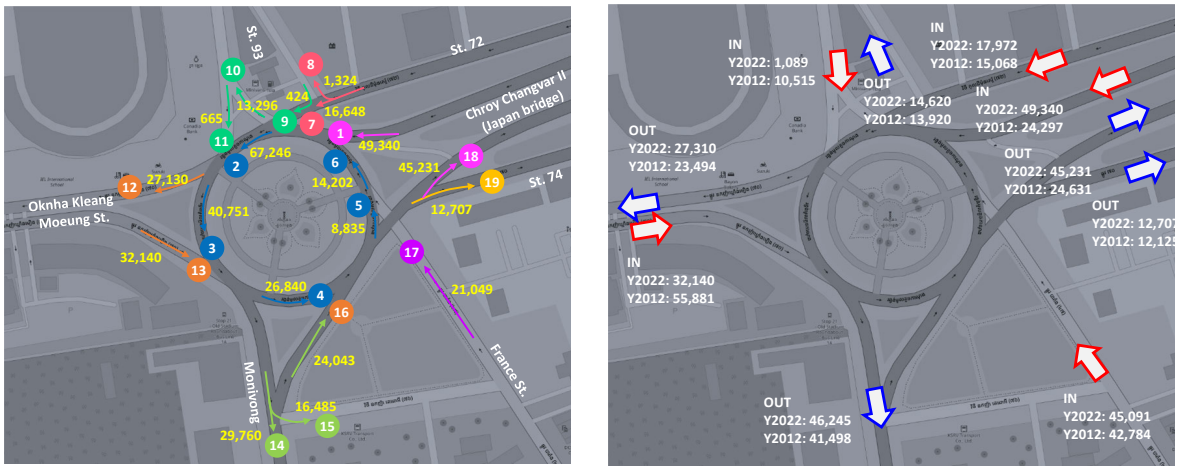
	Inflow Traffic in 2022	Inflow Traffic in 2012	AAGR (%)
IS-08	76,233	86,465	-1.25%
IS-09	171,062	95,422	6.01%
IS-10	137,791	96,350	3.64%
IS-11	144,139	114,672	2.31%
IS-13	65,369	50,077	2.70%
IS-15	112,730	N/A	
Total	**1,371,512**	**1,075,315**	**2.46%**

Unit: PCU/16 hrs
Note: Survey was not conducted at IS-15 in 2012.
Source: JST

2) Result of Traffic Count at IS-01

A new bridge connecting NR-5 and NR-6 is under construction approximately 2.4 km upstream (north side) of Chroy Changver Bridge, and a temporary bridge was open at the time when the Intersection Traffic Survey was conducted in 2022. As a result, traffic from NR-5 to NR-6 was handled by the upstream bridge.

Traffic volume increased from 2012, especially the increase in inflow and outflow to Japan Bridge is particularly remarkable. The flow is getting worse not only in the morning and evening peak. However, this point has many inflow and outflow roads and is not suitable for signal control. Although the underpass proposed in PPUTMP is desired, the discussion has not progressed.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.77 Result of Traffic Count at IS-01

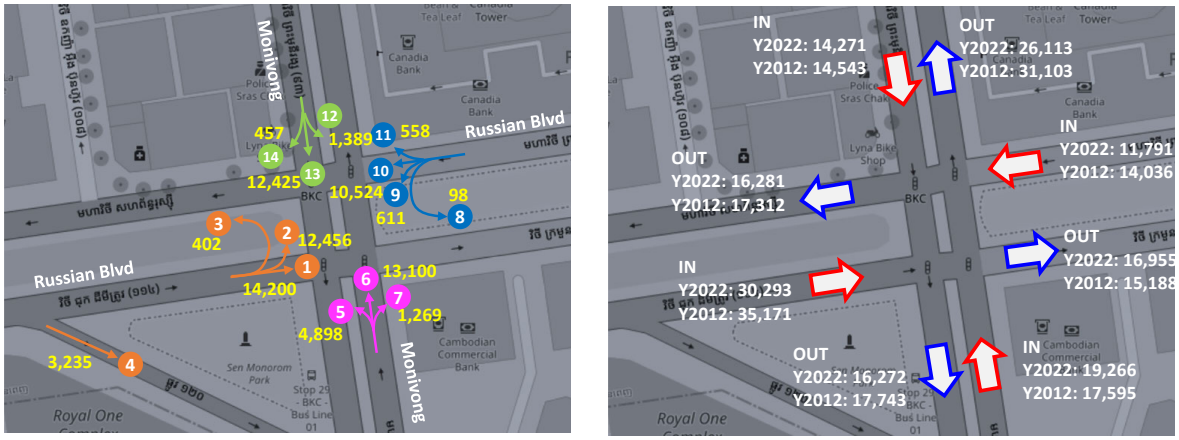
Table 1.3.23 Result of Traffic Count at IS-01

	Oknha Kleang Moeung		St.93		St.72/ St.74		France/ Monivong		Japan Bridge	
Year	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**	**IN**	**OUT**
2022	32,140	27,130	1,089	14,620	17,972	12,707	45,091	46,245	49,340	45,231
2012	29,626	23,494	10,515	13,920	15,068	12,125	42,784	41,498	24,297	24,631
Diff	2,514	3,636	-9,426	699	2,905	582	2,307	4,747	25,044	20,600

Unit: PCU/16 hrs
Source: JST

3) Result of Traffic Count at IS-02

Although the traffic volume of the outflow of Russian East and the inflow of Monivong South has increased slightly, the overall traffic volume of the intersection is decreasing. However, there is a certain amount of traffic congestion during peak hours. This intersection is a target of the training in the Project for Capacity Development on Comprehensive Traffic Control Centre in Phnom Penh Capital City (Technical Cooperation Project) for signal timing optimisation. One of the reasons of traffic congestion at this intersection is the lane reduction due to buildings on the northwest corner.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.78 Result of Traffic Count at IS-02

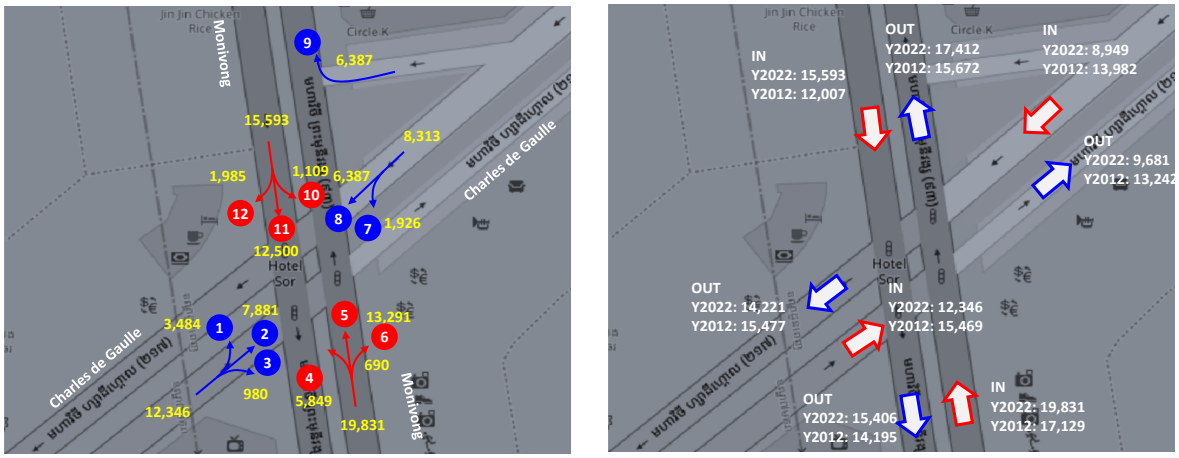
Table 1.3.24 Result of Traffic Count at IS-02

	Monivong North		Russian East		Monivong South		Russian West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	14,271	26,113	11,791	16,955	19,266	16,272	30,293	16,281
2012	14,543	31,103	14,036	15,188	17,595	17,743	35,171	17,312
Diff	-273	-4,990	-2,245	1,767	1,671	-1,471	-4,878	-1,031

Unit: PCU/16 hrs
Source: JST

4) Result of Traffic Count at IS-03

While the traffic volume on Monivong Blvd. increased from 2012, the traffic volume on Charles de Gaulle Blvd. decreased. At this intersection, the distance with adjacent intersections (St.107 on the west side) is also short, so it is important to continue optimal operation through the traffic control system.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.79 Result of Traffic Count at IS-03

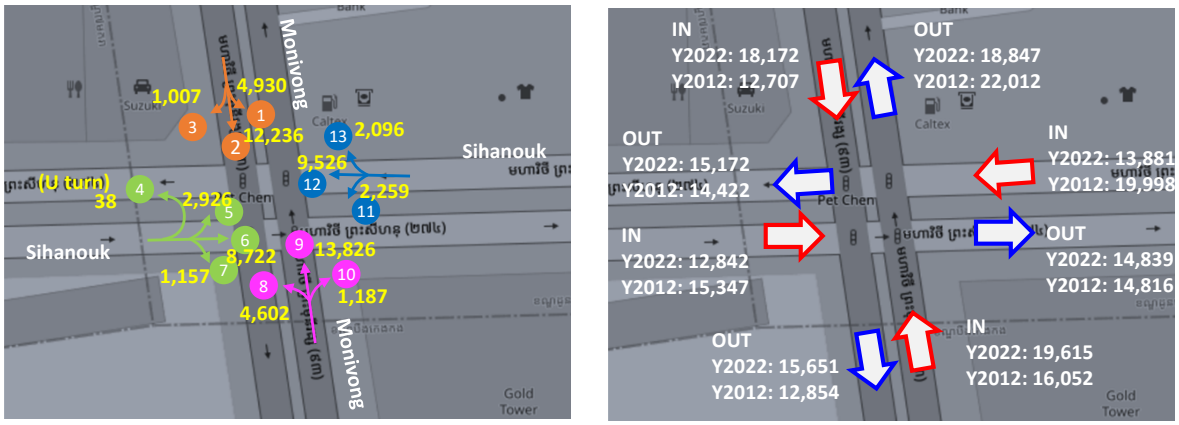
Table 1.3.25 Result of Traffic Count at IS-03

	Charles de Gaulle West		Monivong North		Charles de Gaulle East		Monivong South	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	12,346	14,221	15,593	17,412	8,949	9,681	19,831	15,406
2012	15,469	15,477	12,007	15,672	13,982	13,242	17,129	14,195
Diff	-3,123	-1,256	3,587	1,740	-5,032	-3,561	2,702	1,210

Unit: PCU/16 hrs
Source: JST

5) Result of Traffic Count at IS-04

The traffic volume by direction slightly increased or decreased, and there is no major problem in terms of traffic management at this intersection alone.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.80 Result of Traffic Count at IS-04

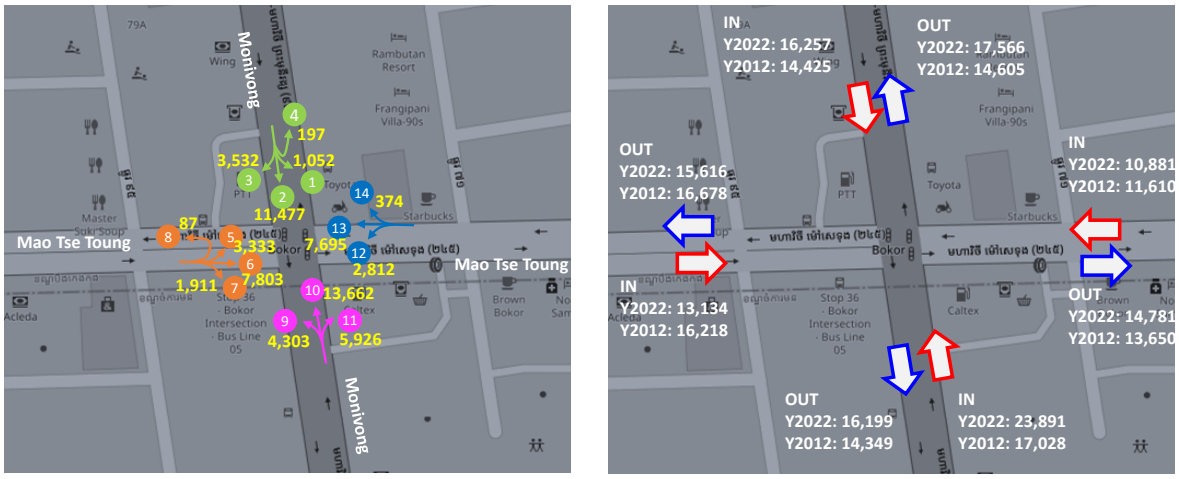
Table 1.3.26 Result of Traffic Count at IS-04

	Monivong North		Sihanouk East		Monivong South		Sihanouk West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	18,172	18,847	13,881	14,839	19,615	15,651	12,842	15,172
2012	12,707	22,012	19,998	14,816	16,052	12,854	15,347	14,422
Diff	5,465	-3,165	-6,117	23	3,562	2,798	-2,504	750

Unit: PCU/16 hrs
Source: JST

6) Result of Traffic Count at IS-05

Although there is an increasing trend in traffic volume in the direction of Monivong Blvd., there are no major issues in terms of traffic management at this intersection alone.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.81 Result of Traffic Count at IS-05

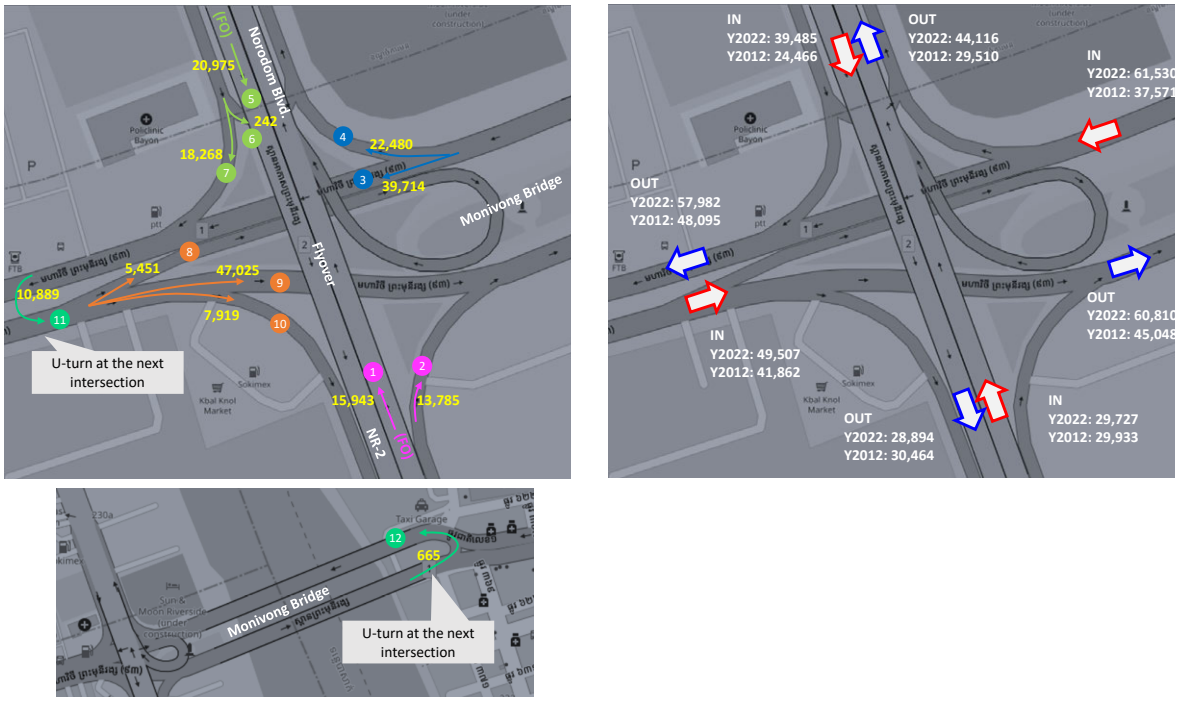
Table 1.3.27 Result of Traffic Count at IS-05

	Monivong North		Mao Tse Toung East		Monivong South		Mao Tse Toung West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	16,257	17,566	10,881	14,781	23,891	16,199	13,134	15,616
2012	14,425	14,605	11,610	13,650	17,028	14,349	16,218	16,678
Diff	1,832	2,962	-729	1,131	6,863	1,851	-3,084	-1,061

Unit: PCU/16 hrs
Source: JST

7) Result of Traffic Count at IS-06

This intersection is the grade separation with a flyover of the north-south direction (Norodom Blvd. - NR-2) and has a high increase rate of traffic volume except for the NR 2 direction. As there are no left turn lanes from Norodom (north) and NR-2 (south), the traffic must turn right and make a U-turn at Monivong or NR 1. As a result, further traffic congestion occurs at the U-turn sections which are the #55 intersection and the east end of Monivong Bridge. Therefore, the countermeasures for this left-turn traffic are an urgent issue.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.82 Result of Traffic Count at IS-06

Table 1.3.28 Result of Traffic Count at IS-06

	Norodom North		Monivong Bridge		NR-2		Monivong West	
	IN	OUT	IN*	OUT*	IN	OUT	IN**	OUT**
2022	39,485	44,116	61,530	60,810	29,727	28,894	49,507	57,982
2012	24,466	29,510	37,571	45,048	29,933	30,464	41,862	48,095
Diff	15,019	14,606	23,958	15,762	-206	-1,570	7,645	9,888

Note 1: U-turn traffic (Direction 12) is excluded from Monivong Bridge (IN) but included in Monivong Bridge (OUT).
Note 2: U-turn traffic (Direction 11) is excluded from Monivong West (IN) but included in Monivong West (OUT).
Unit: PCU/16 hrs
Source: JST

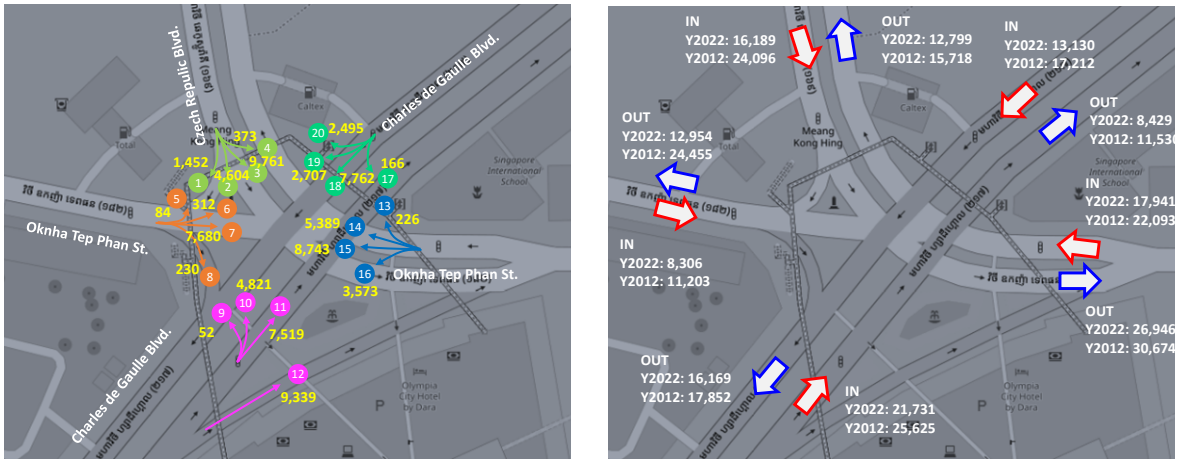
The #55 intersection on the west side of this intersection is planned to be connected to the expressway from the new Phnom Penh International Airport. The construction of the three-level grade separation at the #55 intersection started on 26 August, 2022; and since it is expected to have an impact on the intersection, it is necessary to consider physical and soft countermeasures integrated with the surrounding intersections.

Source: Phnom Penh Post issued on 26 August, 2022

Figure 1.3.83 Government Proposal for Three-level Grade Separation Plan at Intersection #55

8) Result of Traffic Count at IS-07

Traffic volume is on a downward trend. After the completion of the grant aid project for the signalling system, a pedestrian crossing bridge was installed across the entire intersection. The angle of view of the vehicle detector is obstructed by advertising signs on the pedestrian bridge. In other words, the traffic control system may not be functioning correctly, so functional improvement through the technical support project is an urgent task in terms of traffic management.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.84 Result of Traffic Count at IS-07

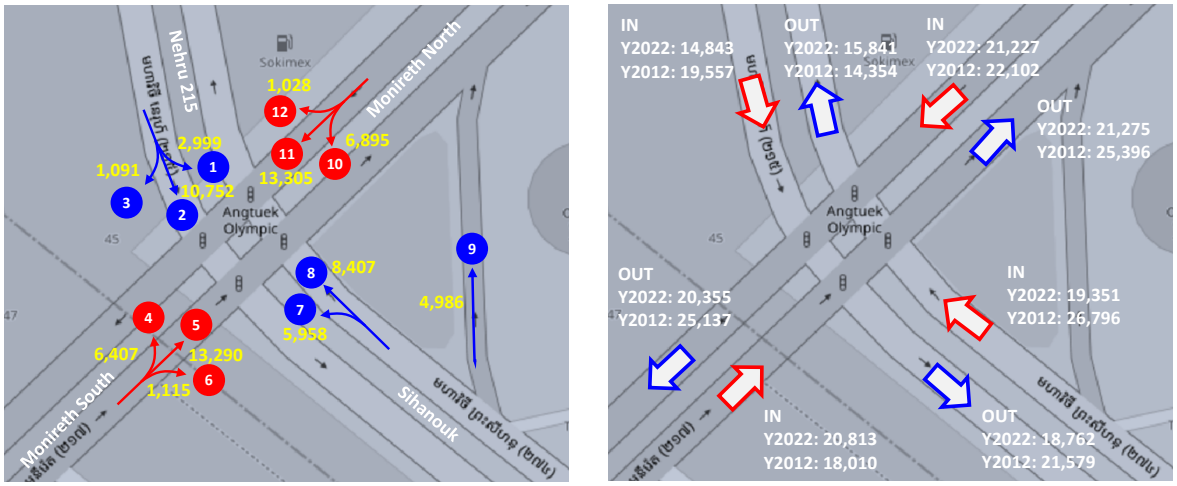
Table 1.3.29 Result of Traffic Count at IS-07

	Czech Republic		Charles de Gaulle North		Oknha East		Charles de Gaulle South		Oknha West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	16,189	12,799	13,130	8,429	17,941	26,946	21,731	16,169	8,306	12,954
2012	24,096	15,718	17,212	11,530	22,093	30,674	25,625	17,852	11,203	24,455
Diff	-7,907	-2,920	-4,082	-3,102	-4,153	-3,728	-3,894	-1,684	-2,898	-11,501

Unit: PCU/16 hrs
Source: JST

9) Result of Traffic Count at IS-08

It is an intersection where bus priority lanes are planned to be installed. The traffic volume is on a downward trend here but there is a need to consider the influence of adjacent intersections. On the other hand, the intersection area is wide, so it is desirable to make it compact and to streamline traffic flow for improving safety and minimizing the passing time.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.85 Result of Traffic Count at IS-08

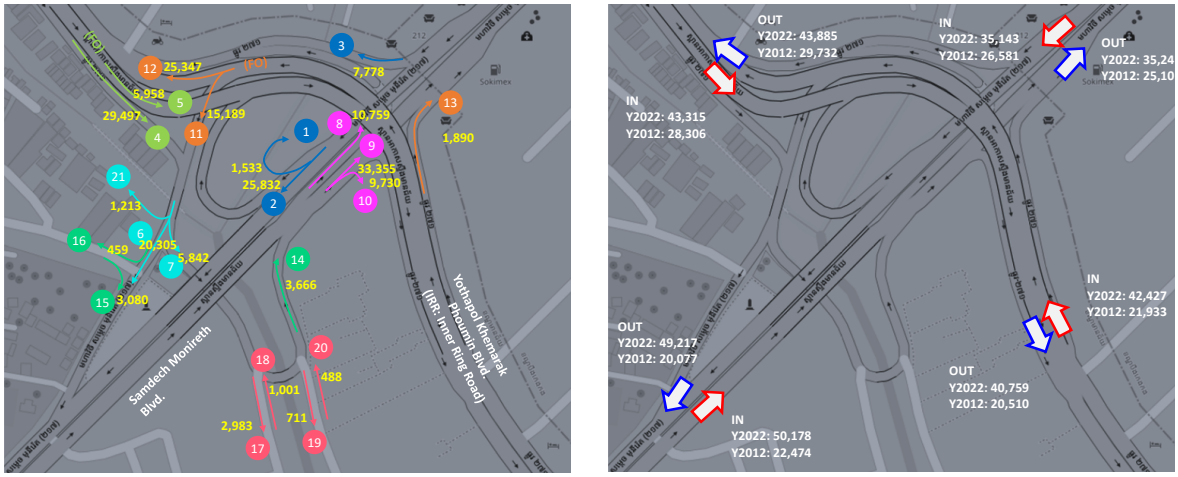
Table 1.3.30 Result of Traffic Count at IS-08

	Nehru 215		Monireth North		Sihanouk		Monireth South	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	14,843	15,841	21,227	21,275	19,351	18,762	20,813	20,355
2012	19,557	14,354	22,102	25,396	26,796	21,579	18,010	25,137
Diff	-4,714	1,488	-875	-4,121	-7,446	-2,816	2,803	-4,782

Unit: PCU/16 hrs
Source: JST

10) Result of Traffic Count at IS-09

Traffic volume increased in all directions. At the time of the 2012 survey, the flyover was still under construction while the flyover was already in operation when the survey was conducted in 2022. There are no major issues in terms of traffic management at this intersection alone.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.86 Result of Traffic Count at IS-09

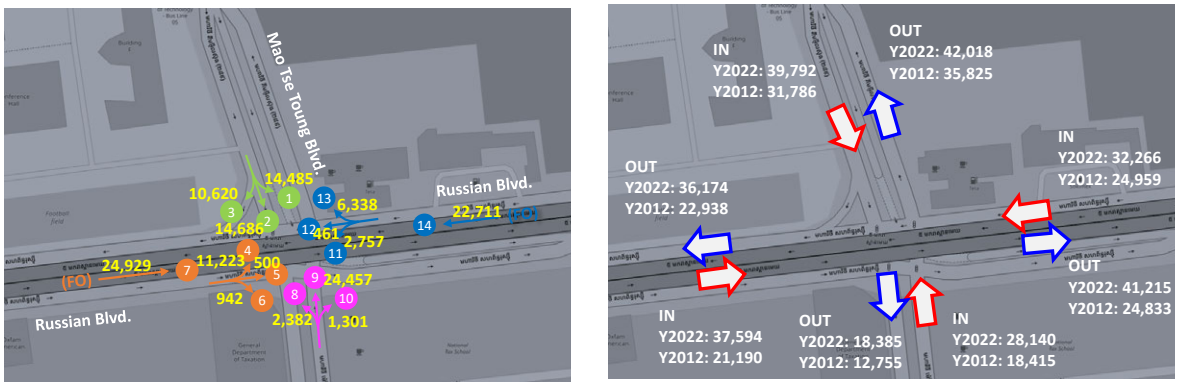
Table 1.3.31 Result of Traffic Count at IS-09

	Monireth North		IRR South		Monireth South		IRR North	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	35,143	35,245	42,427	40,759	50,178	49,217	43,315	43,885
2012	26,581	25,103	21,933	20,510	22,474	20,077	28,306	29,732
Diff	8,562	10,142	20,493	20,249	27,704	29,139	15,009	14,153

Unit: PCU/16 hrs
Source: JST

11) Result of Traffic Count at IS-10

The increasing trend of traffic volume is remarkable in all directions. The intersection structure is grade separation, and there are no major issues in terms of traffic management.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.87 Result of Traffic Count at IS-10

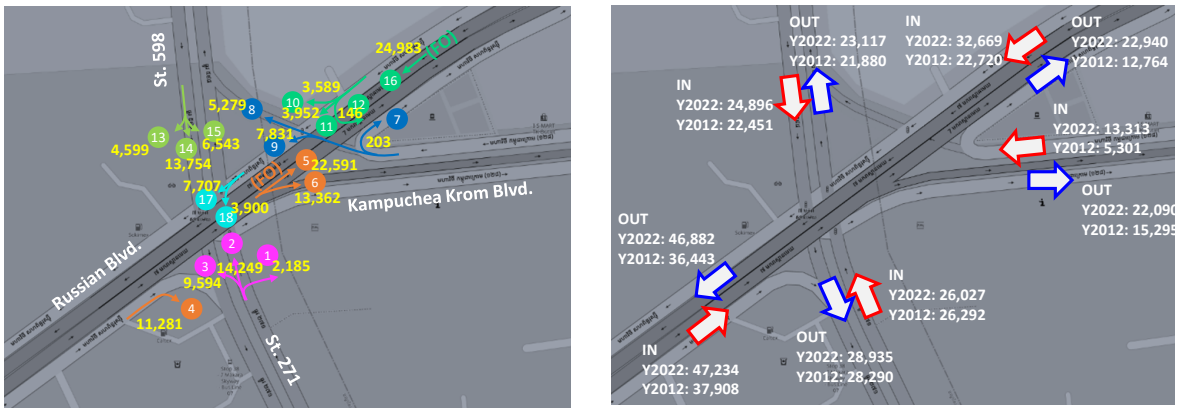
Table 1.3.32 Result of Traffic Count at IS-10

	Mao Tes Toung North		Russian East		Mao Tes Toung South		Russian West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	39,792	42,018	32,266	41,215	28,140	18,385	37,594	36,174
2012	31,786	35,825	24,959	24,833	18,415	12,755	21,190	22,938
Diff	8,006	6,193	7,307	16,382	9,725	5,630	16,404	13,236

Unit: PCU/16 hrs
Source: JST

12) Result of Traffic Count at IS-11

The traffic volume of the all directions increased. The intersection structure is grade separation, and there are no major issues in terms of traffic management.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.88 Result of Traffic Count at IS-11

Table 1.3.33 Result of Traffic Count at IS-11

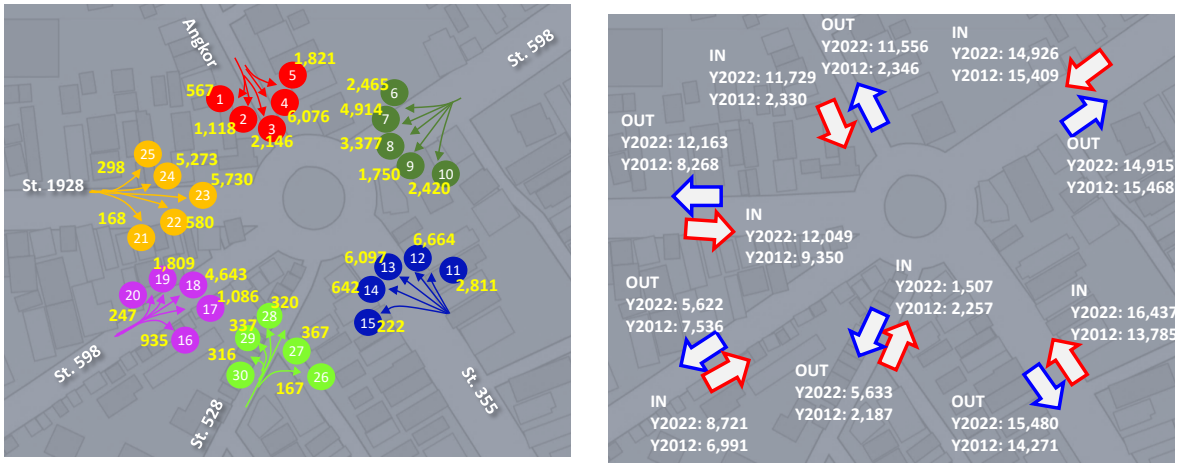
	St 598		Russian East		Kampuchea Krom		St 271		Russian West	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	24,896	23,117	32,669	22,940	13,313	22,090	26,027	28,935	47,234	46,882
2012	22,451	21,880	22,720	12,764	5,301	15,295	26,292	28,290	37,908	36,443
Diff	2,445	1,237	9,950	10,176	8,012	6,795	-265	645	9,326	10,439

Unit: PCU/16 hrs
Source: JST

13) Result of Traffic Count at IS-13

The traffic volume of this intersection increased from 2012. It is an important intersection that connects the rapidly developing Sen Sok District represented by AEON 2, and the city centre of Phnom Penh. It used to be a roundabout, but it has been converted to a signalized intersection, which is not networked with the Traffic Control Centre (TCC).

As it used to be a roundabout, the area of the intersection was wide. Therefore, it is necessary to redesign it to minimize vehicle passing time to improve safety. It is also recommended to incorporate this intersection into the TCC network in the future.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.89 Result of Traffic Count at IS-13

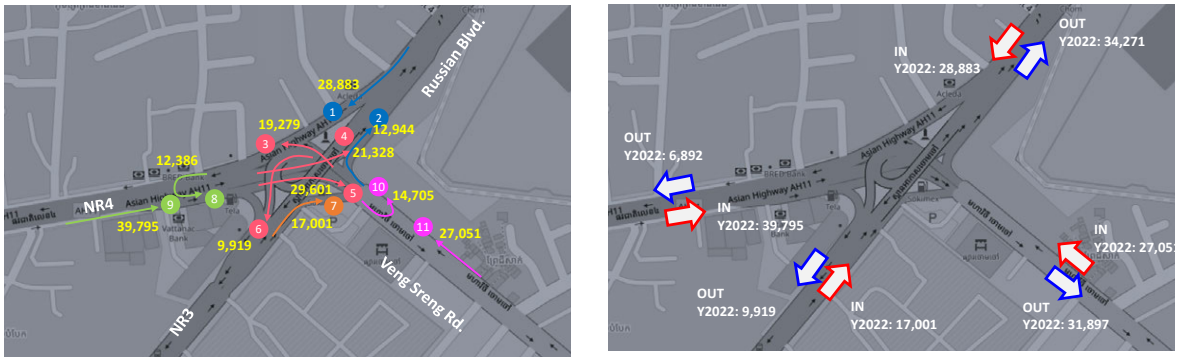
Table 1.3.34 Result of Traffic Count at IS-13

	St 598 East		St 355		St 528		St 598 West		St 1928		Angkor	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	14,926	14,915	16,437	15,480	1,507	5,633	8,721	5,622	12,049	12,163	11,729	11,556
2012	15,409	15,468	13,785	14,271	2,257	2,187	6,991	7,536	9,350	8,268	2,330	2,346
Diff	-483	-553	2,652	1,208	-750	3,446	1,729	-1,915	2,699	3,895	9,400	9,210

Unit: PCU/16 hrs
Source: JST

14) Result of Traffic Count at IS-15

As the starting point of NR-3 and NR-4, it is an important intersection connecting surrounding cities and Phnom Penh. Currently the construction of grade separation is ongoing. There are no major problems in terms of traffic management in the current situation.



Unit: PCU/16 hrs
Source: JST

Figure 1.3.90 Result of Traffic Count at IS-15

Table 1.3.35 Result of Traffic Count at IS-15

	Russian		Veng Sreng		NR3		NR4	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
2022	28,883	34,271	27,051	31,897	17,001	9,919	39,795	6,892

Note1: No traffic count was conducted in 2012.
Note2: All traffic from NR-3 goes to Veng Sreng Rd. due to the construction.
Note3: NR-4 to NR-3 route is restricted due to the construction.
Unit: PCU/16 hrs
Source: JST

1.3.7 Travel Speed Survey (TSS)

(1) Outline

Travel Speed Survey (TSS) was conducted to measure the travel time between the major road sections, with a view to identifying traffic congestion points that need to be addressed. The survey consists of the following:

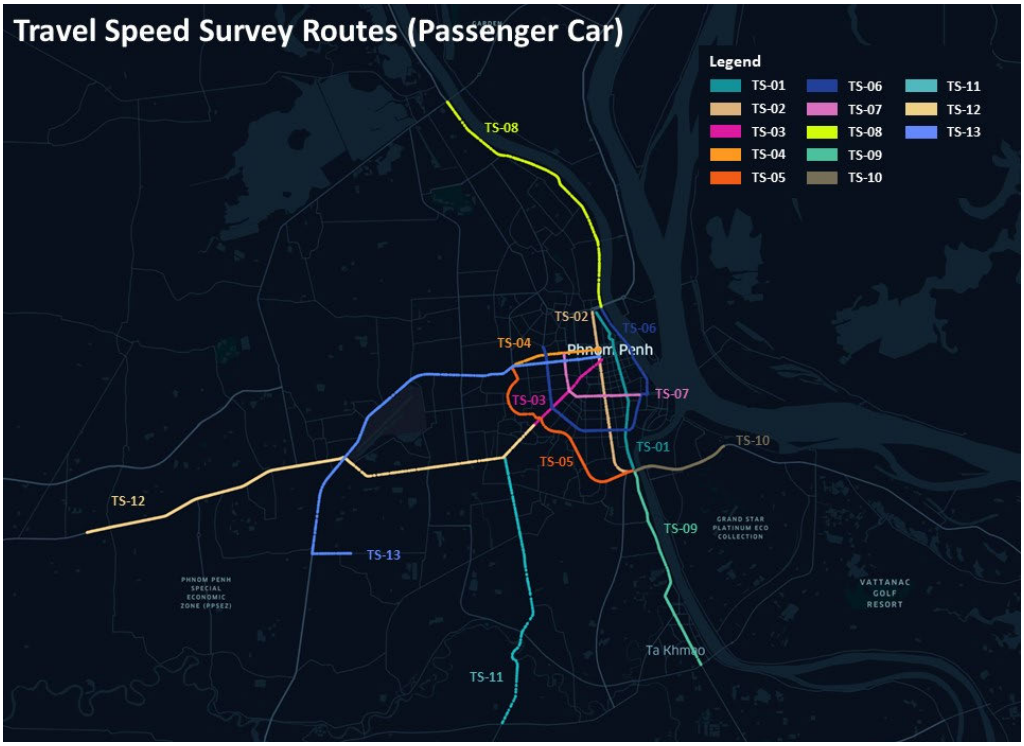
- Travel Speed Survey for Passenger Cars;
- Travel Speed Survey for Ride-Hailing Service (tuk-tuk);
- Travel Speed Survey for Commuter Bus; and
- Travel Speed Survey for City Bus

(2) Survey Coverage

1) Travel Speed Survey for Passenger Cars

Travel Speed Survey for Passenger Cars was conducted on 13 routes in Phnom Penh shown in Figure 1.3.91 and Table 1.3.36. Each route was measured by three round trips for three different times of the day: morning peak hours (7:00-9:00), evening peak hours (17:00-19:00) and off-peak hours (12:00-14:00). The survey day was a weekday from Tuesday to Thursday excluding Saturday, Sunday and public holidays. The survey was conducted by the "floating car method" which requires the surveyed vehicle to keep the same position in the traffic flow, i.e., if the surveyed vehicle is overtaken by other vehicles, it should overtake the same number of vehicles. The following travel information was collected.

- Time of departure and arrival (start and end points of route)
- Time of passing checkpoints
- Time of stop/restart with reason of stopping



Source: JST

Figure 1.3.91 Travel Speed Survey Routes for Passenger Cars

Table 1.3.36 Travel Speed Survey Routes for Passenger Cars

Route	Street Name	Start	End
Routes in CBD			
TS-01	France/ Norodom (Rd 47/41)	Chruoy Changvar Roundabout	Monivong Flyover Bridge
		Monivong Flyover Bridge	Chruoy Changvar Roundabout
TS-02	Monivong Blvd.	Chruoy Changvar Roundabout	Monivong Flyover Bridge
		Monivong Flyover Bridge	Chruoy Changvar Roundabout
TS-03	Charles De Gaulle/Monireth (Rd 217)	Central Market	Steung Meanchey Flyover
		Steung Meanchey Flyover	Central Market
TS-04	Russian Blvd.	Canadia Bank Tower	Pet Loksang Flyover Bridge
		Pet Loksang Flyover Bridge	Canadia Bank Tower
TS-05	Inner Ring Road (Rd 271)	Pet Loksang Flyover Bridge	Monivong Flyover Bridge
		Monivong Flyover Bridge	Pet Loksang Flyover Bridge
TS-06	Sisowath/Sothearos/Mao Tsetung/Kim il Sung (Rd 1/3/245/289)	Toul Kork Roundabout	Chruoy Changvar Bridge
		Chruoy Changvar Bridge	Toul Kork Roundabout
TS-07	Sihanouk/Nehru Blvd. (Rd 274/215)	Sihanouk Blvd -Sothearos Intersection	Nehru-Russian Blvd. Intersection
		Nehru-Russian Blvd. Intersection	Sihanouk Blvd -Sothearos Intersection
Routes outside CBD			
TS-08	NR5 Along City Bus Line1	Chruoy Changvar Roundabout	Prek Pnov Bridge
		Prek Pnov Bridge	Chruoy Changvar Roundabout
TS-09	NR2/ St.211/ St.21 Along City Bus Line2	Monivong Flyover Bridge	Prek Samrong Bridge
		Prek Samrong Bridge	Monivong Flyover Bridge

Route	Street Name	Start	End
TS-10	NR1 Along City Bus Line1	Monivong Flyover Bridge	Boeng Chhouk
		Boeng Chhouk	Monivong Flyover Bridge
TS-11	Chamkar Doung St. Along City Bus Line 4C	Steung Meanchey Intersection	Prek Kampues
		Prek Kampues	Steung Meanchey Intersection
TS-12	Monireth/ Veng Sreng/ NR4 Along City Bus Line 4	Steung Meanchey Flyover	Chengdu Bayi Sino-Cambodia Trade City
		Chengdu Bayi Sino-Cambodia Trade City	Steung Meanchey Flyover
TS-13	Kampuchea Krom/ Russian Blvd./ NR3 Along City Bus Line3	PPCBank Central Market Branch	Borey Son Ti Pheap2
		Borey Son Ti Pheap2	PPCBank Central Market Branch

Source: JST

2) Travel Speed Survey for Ride-Hailing Service (tuk-tuk)

The movement of Ride Hailing Service (tuk-tuk) was recorded by GPS equipment which encodes the travel log data containing coordinates (latitude, longitude), time, and others. The outline is described as the table below.

Table 1.3.37 Outline of Travel Speed Survey for RHS

Survey duration	• 07:00 to 19:00 on weekdays from Tuesday through Thursday excluding Saturday, Sunday and public holidays.
Survey locations	• City Centre: 3 locations (Central Market, Boeung Keng Kang Market and Russian Market) • Suburb: 2 locations (Russei Keo Market (NR-5) and Chom Chao Market (western Airport)
No of samples	• 5 locations x 5 drivers/day x 2 days = 50 samples

Source: JST

3) Travel Speed Survey for Commuter Bus/Truck

Commuter Bus/Truck is a private bus or truck hired by a company for its employees' commutes. Commuter Bus/Truck movement was recorded by GPS equipment which encodes the travel log data containing coordinates (latitude, longitude), time, and others. The outline of the survey is summarised as below.

Table 1.3.38 Outline of Travel Speed Survey for Commuter Bus/Truck

Survey duration	• **Morning peak hours (07:00-09:00)** of weekdays from Tuesday to Thursday excluding Saturday, Sunday and public holidays. • **Evening peak hours (17:00-19:00)** of weekdays from Tuesday to Thursday excluding Saturday, Sunday and public holidays.
Survey Target	• The original target routes were the Commuter Bus routes from the CBD to the PPSEZ. • Due to the commuter bus operation policy change after the COVID-19 pandemic by major companies at PPSEZ, it became difficult to collect data from the original targets as most companies suspended the operation. Thus, the target was changed to the Commuter Bus route in Phnom Penh and Commuter Truck operated around PPSEZ.
No of samples	• 25 routes/day x 2 days = 50 samples

Source: JST

4) Travel Speed Survey for City Bus

Due to the COVID-19 pandemic, the routes of City Bus in operation are limited to four major routes, namely, Line 1, Line 2, Line 3, Line 4A and Line 4B. The GPS data was collected for these routes in operation through a pre-equipped device on each bus.

(3) Survey Result

1) Result of Travel Speed Survey (Passenger Car)

Table 1.3.39 and Figure 1.3.92 describe the average travel speed of passenger cars. In general, the average travel speed outside CBD is higher than the travel speed in CBD. Travel speed in CBD slows down the most to 14.0 km/h for the inbound direction and 11.5 km/h for the outbound direction in the evening peak hours. Similarly, the travel speed outside CBD was lowest at 17.0 km/h for the outbound direction in the evening peak hours.

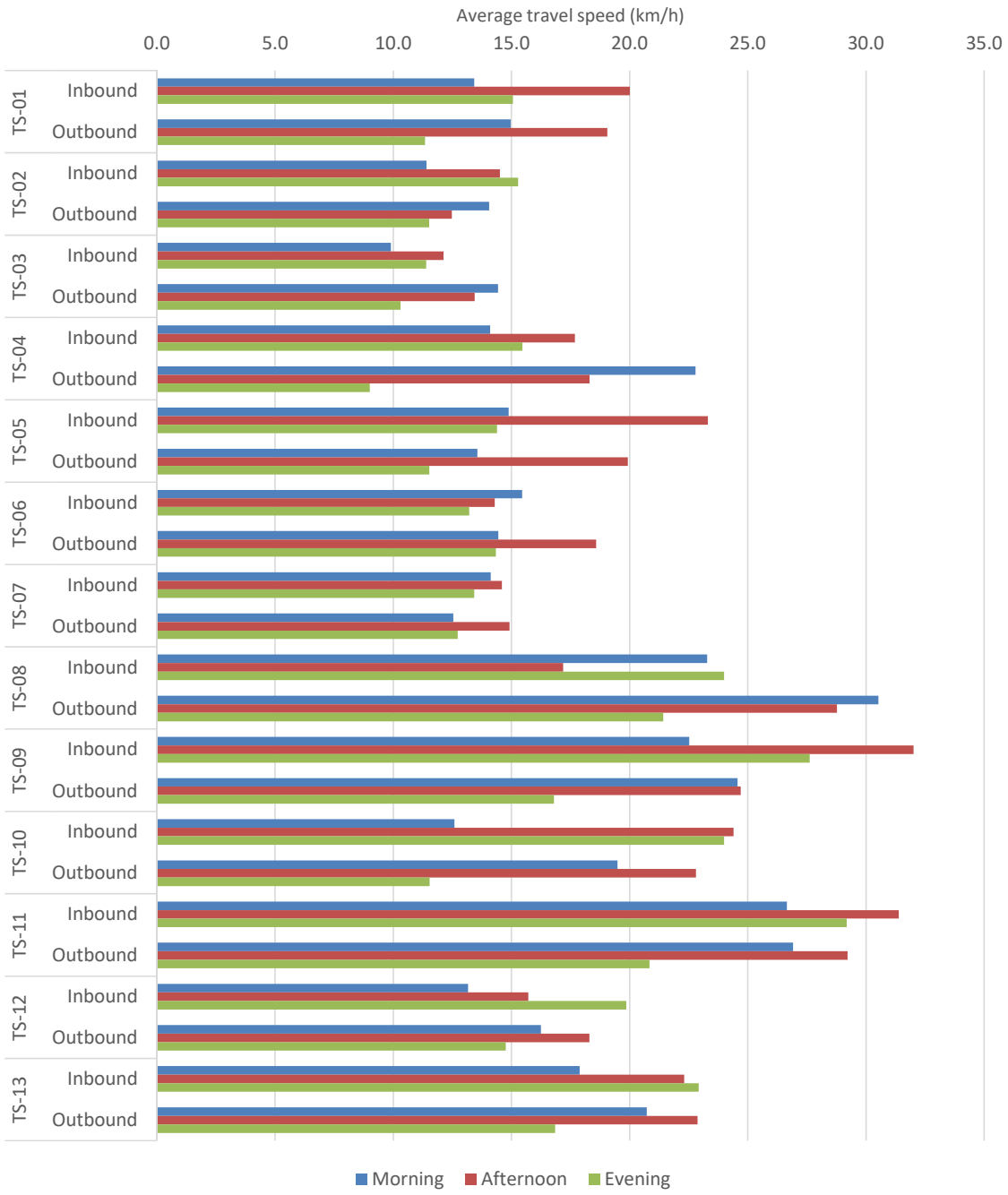
Overall, the lowest travel speed of 9.0 km/h was recorded on TS-04 (Russian Blvd.) in the outbound traffic during the evening peak hours. In addition, the survey result suggests that TS-03 (Charles De Gaulle/Monireth) is more severely congested among these routes during peak hours.

Table 1.3.39 Average Travel Speed (Passenger Car)

Route ID / Street Name	Direction	Average Travel Speed (km/h)		
		Morning 7:00-9:00	Afternoon 12:00-14:00	Evening 17:00-19:00
TS-01 France/ Norodom (Rd 47/41)	Inbound	13.4	20.0	15.1
	Outbound	15.0	19.1	11.3
TS-02 Monivong Blvd.	Inbound	11.4	14.5	15.3
	Outbound	14.1	12.5	11.5
TS-03 Charles De Gaulle/Monireth (Rd 217)	Inbound	9.9	12.1	11.4
	Outbound	14.4	13.4	10.3
TS-04 Russian Blvd.	Inbound	14.1	17.7	15.5
	Outbound	22.8	18.3	9.0
TS-05 Inner Ring Road (Rd 271)	Inbound	14.9	23.3	14.4
	Outbound	13.6	19.9	11.5
TS-06 Sisowath/Sothearos/Mao Tsetung/Kim Il Sung (Rd 1/3/245/289)	Inbound	15.5	14.3	13.2
	Outbound	14.4	18.6	14.3
TS-07 Sihanouk/Nehru Blvd. (Rd 274/215)	Inbound	14.1	14.6	13.4
	Outbound	12.5	14.9	12.7
TS-08 NR5 (City Bus Line1)	Inbound	23.3	17.2	24.0
	Outbound	30.5	28.8	21.4
TS-09 NR2/ St.211/ St.21A (City Bus Line2)	Inbound	22.5	32.0	27.6
	Outbound	24.6	24.7	16.8
TS-10 NR1 (City Bus Line1)	Inbound	12.6	24.4	24.0
	Outbound	19.5	22.8	11.5
TS-11 Chamkar Doung St. (City Bus Line 4C)	Inbound	26.7	31.4	29.2
	Outbound	26.9	29.2	20.8
TS-12 Monireth/ Veng Sreng/ NR4 (City Bus Line 4)	Inbound	13.2	15.7	19.9
	Outbound	16.2	18.3	14.8
TS-13 Kampuchea Krom/ Russian Blvd./ NR3 (City Bus Line3)	Inbound	17.9	22.3	22.9
	Outbound	20.7	22.9	16.8

Route ID / Street Name	Direction	Average Travel Speed (km/h)		
		Morning 7:00-9:00	Afternoon 12:00-14:00	Evening 17:00-19:00
Average Travel Speed in CBD (TS-01 to TS-07)	**Inbound**	**13.3**	**16.7**	**14.0**
	Outbound	**15.3**	**16.7**	**11.5**
Average Travel Speed outside CBD (TS-08 to TS-13)	**Inbound**	**19.4**	**23.8**	**24.6**
	Outbound	**23.1**	**24.4**	**17.0**

Note: TS-09's inbound routes and outbound routes are different.
Note: Outbound of circular routes (TS-05, TS-06, TS-07) indicate counter clock wise direction.
Source: JST

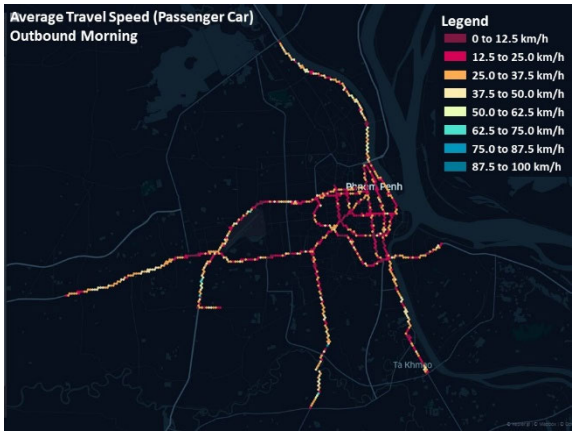


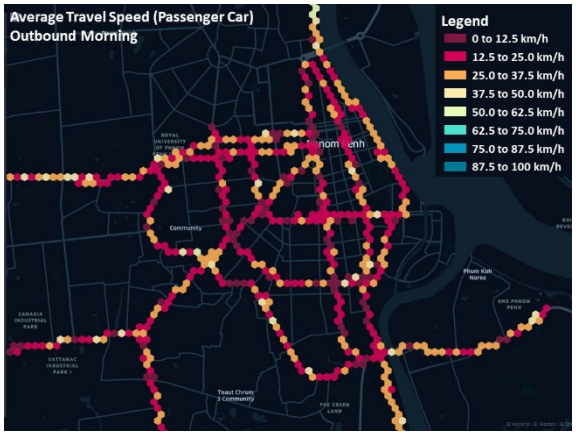
Source: JST

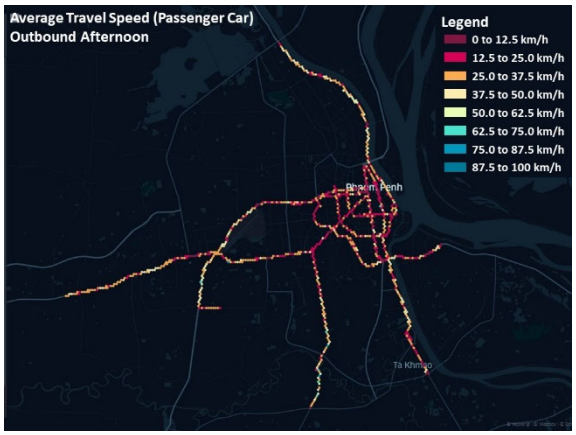
Figure 1.3.92 Average Travel Speed (Passenger Car)

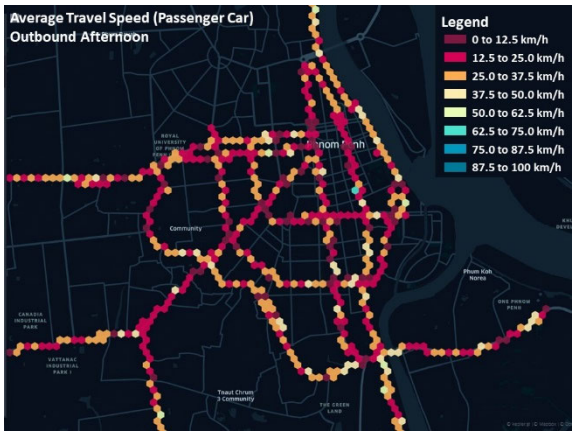
Figure 1.3.93 and Figure 1.3.94 illustrate the average travel speed of the surveyed routes by directions. Heavy traffic congestions were observed at segments near major intersections, where it can be a bottleneck of traffic flow. In particular, the intersection of Monivong Blvd. (NR-1) and Norodom Blvd. (NR-2) near the Monivong Bridge was identified as one of the most congested segments during peak hours as two national roads are connected. In addition, some turning movements are restricted there, which further deteriorates the traffic condition.

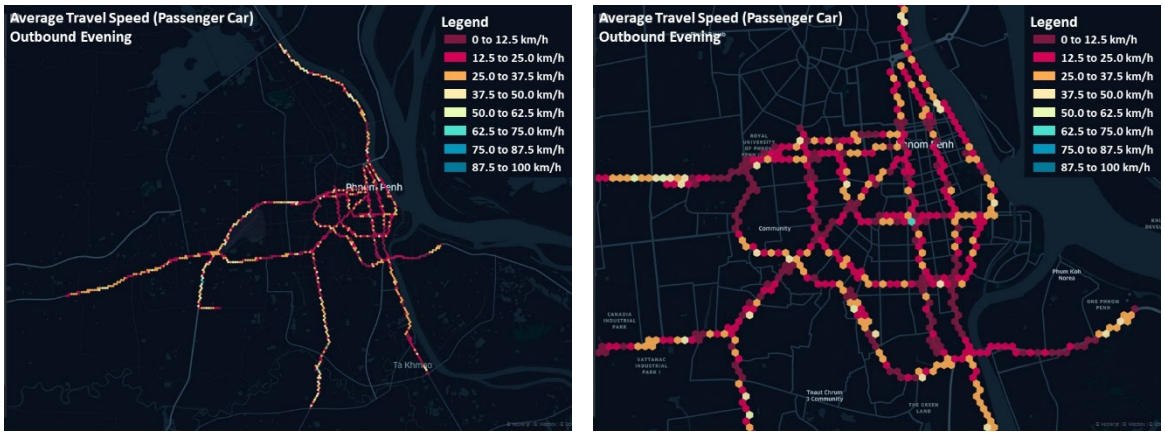
Almost all sections on Charles de Gaulle Blvd., Monireth Blvd. and Veng Sreng Blvd. are heavily congested all day long. The new development in western suburbs in Phnom Penh is considered as a cause of the heavy traffic burden on these arterial roads.





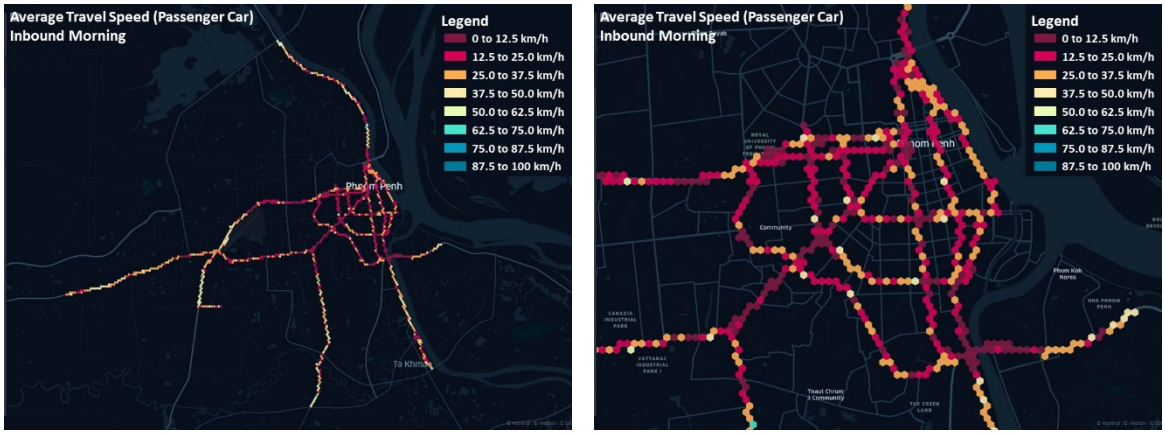


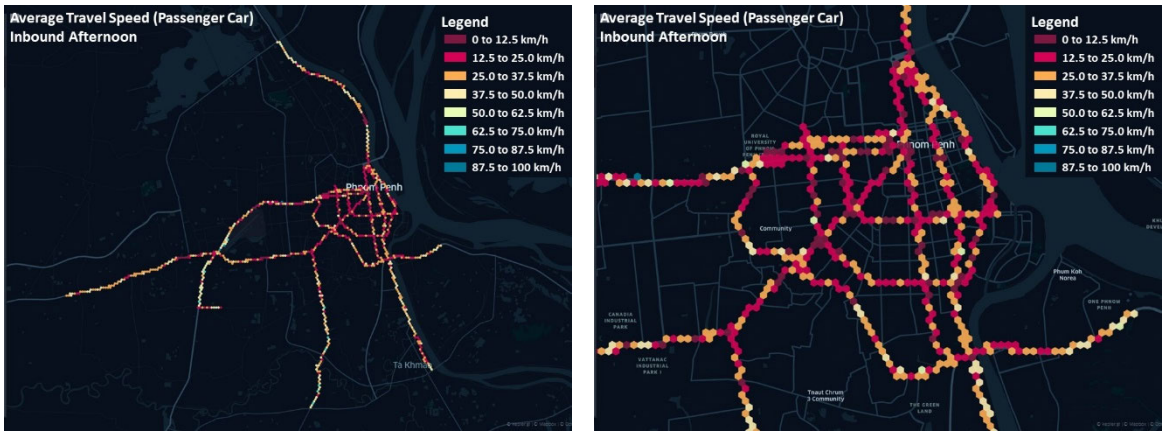


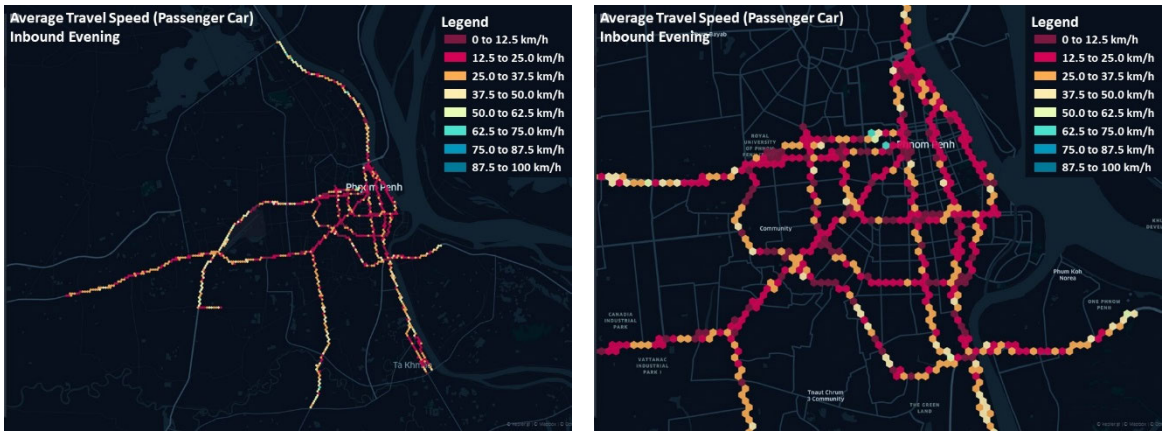


Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.93 Average Travel Speed (Passenger Car) (Outbound)



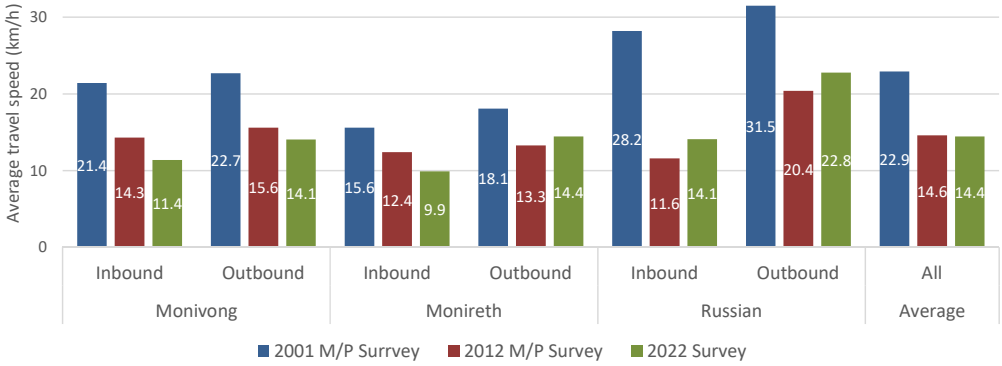




Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.94 Average Travel Speed (Passenger Car) (Inbound)

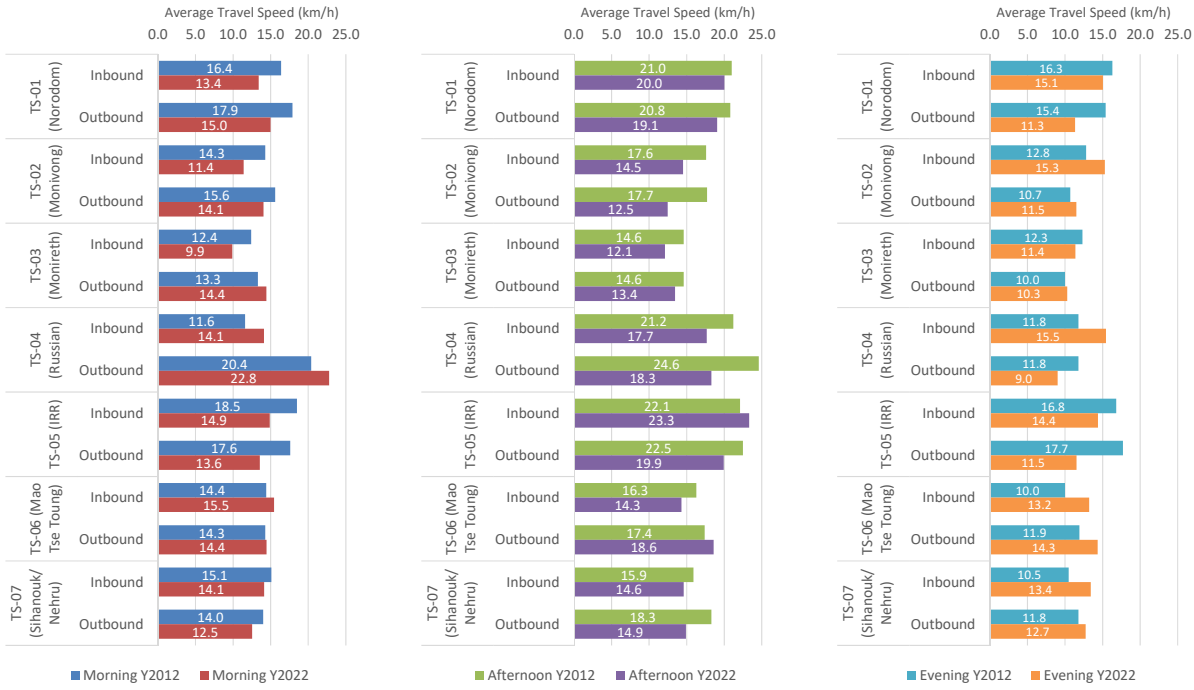
Figure 1.3.95 describes the average travel speed on major corridors during morning peak hours. According to the travel speed surveys in 2001, 2012 and 2022, the gradual decline with travel speed is observed except for Russian Blvd. The improvement on Russian Blvd is considered from the construction of two flyovers: Techno Sky Bridge and Seven Makara Sky Bridge.



Source: JST

Figure 1.3.95 Comparison of Average Travel Speed (Morning Peak) (2001, 2012 and 2022)

Figure 1.3.96 compares the average travel speed of each route in 2012 and 2022. The travel speed decreased on most routes, which can be considered due to the increase of vehicle ownership.



Morning Peak (7:00-9:00) **Afternoon (12:00-14:00)** **Evening Peak (17:00-19:00)**

Note: Outbound of circular routes (TS-05, TS-06, TS-07) indicate counter clock wise direction.
IRR: Inner Ring Road

Figure 1.3.96 Comparison of Travel Speed (2012 and 2022)

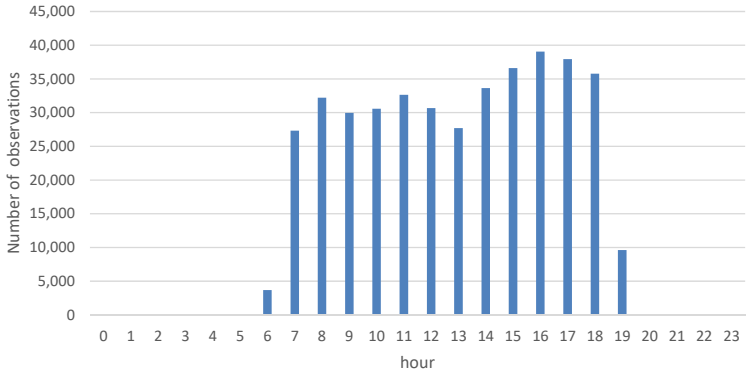
2) Result of Travel Speed Survey (RHS)

GPS records of RHS vehicles were collected to through GPS devices as summarised in Table 1.3.40. The GPS records mostly distribute within the daytime as shown in Figure 1.3.97.

Table 1.3.40 Overview of GPS Records (RHS)

	Station	Number of Samples	GPS Record Date
1	Central Market	5 drivers * 2days	21 to 26 April 2022
2	Bang Keng Kang Market	5 drivers * 2days	27 to 29 April 2022
3	Russian Market	5 drivers * 2days	19 to 21 April 2022, 30 May to 1 June 2022
4	Chaom Chau Market	5 drivers * 2days	1 to 3 May 2022
5	Russei Keo Market	5 drivers * 2days	3 to 5 May 2022

Source: JST



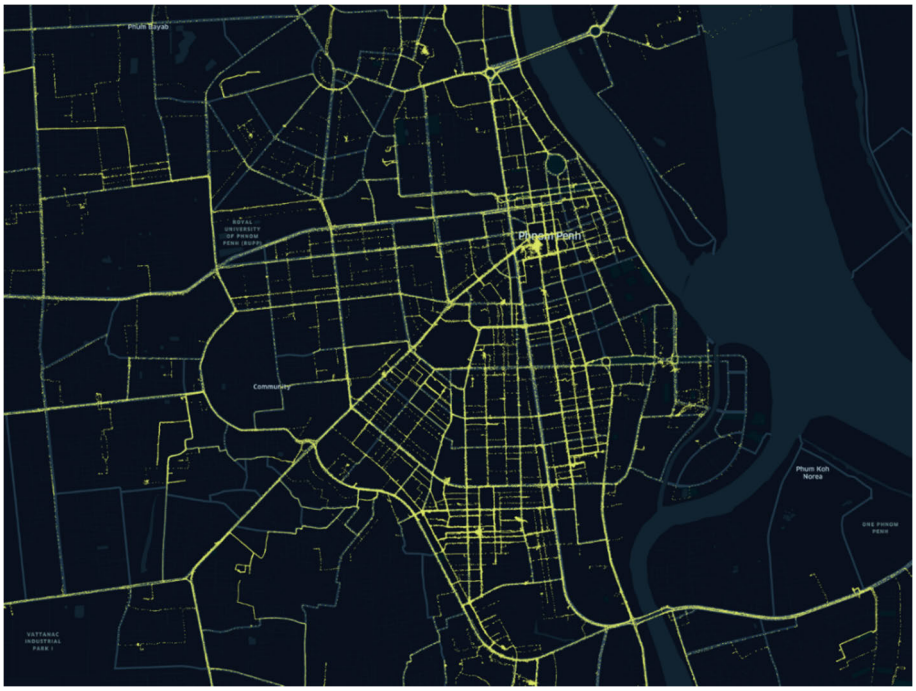
Note: Error records are excluded.
Source: JST

Figure 1.3.97 Distribution of GPS Records

Figure 1.3.98 and Figure 1.3.99 illustrate trajectories of RHS movements. These figures suggest that RHS is widely available in the entire Phnom Penh, particularly in CBD. No travel records were identified on Norodom Blvd., where RHS vehicles are prohibited to drive.

Note: Error records are excluded.
Source: JST

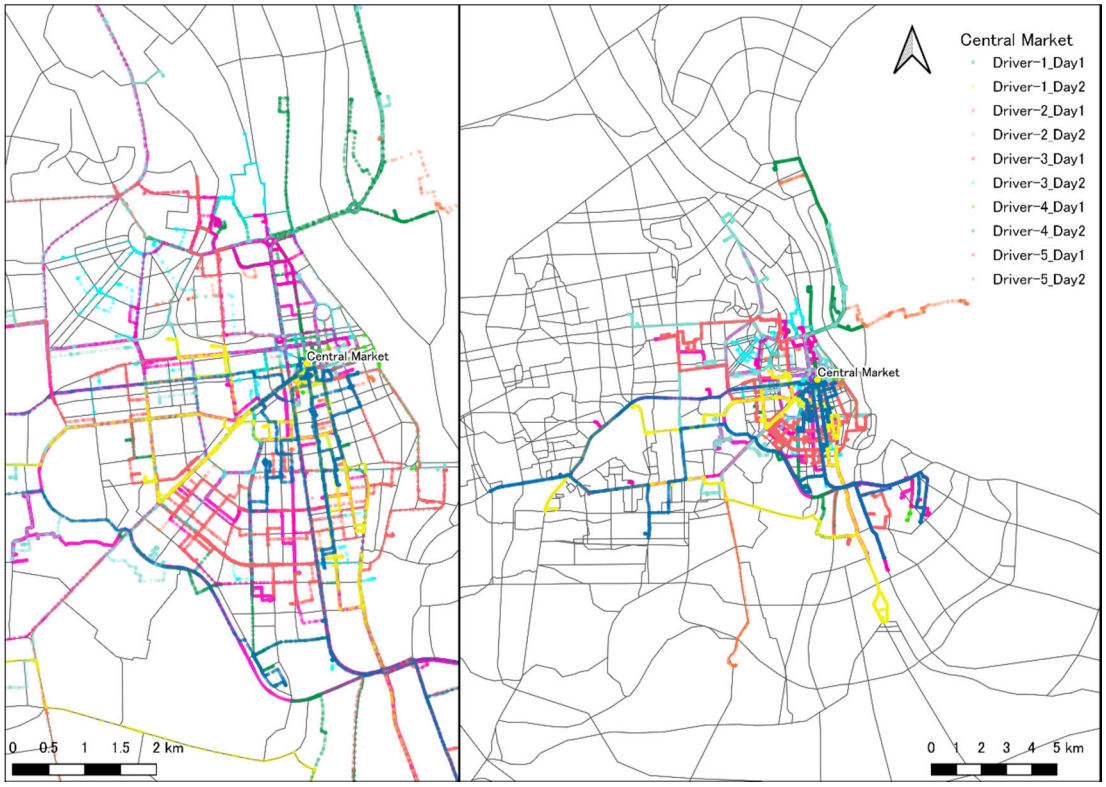
Figure 1.3.98 RHS Vehicle Movements (All records)



Note: Error records are excluded.
Source: JST

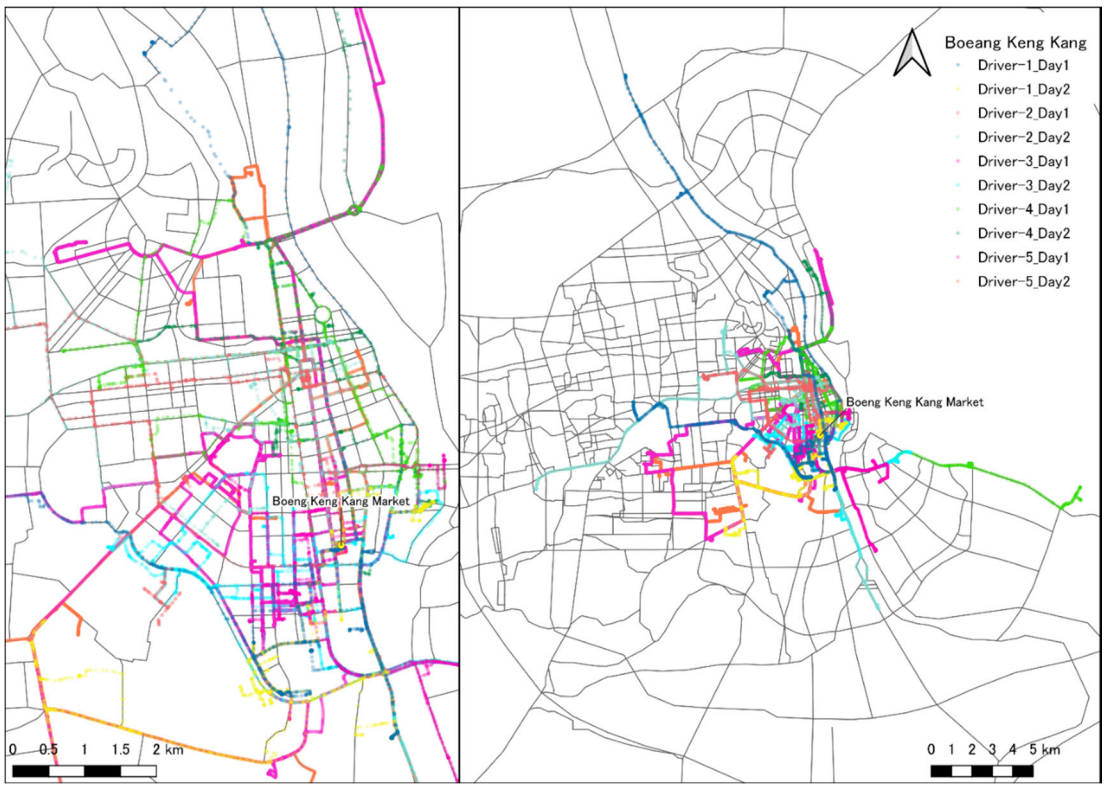
Figure 1.3.99 RHS Vehicle Movements (All Records) (CBD)

Figure 1.3.100 to Figure 1.3.104 illustrate the coverage of RHS stationed at each market. Regardless where RHS vehicles are stationed, GPS records were found throughout Phnom Penh.



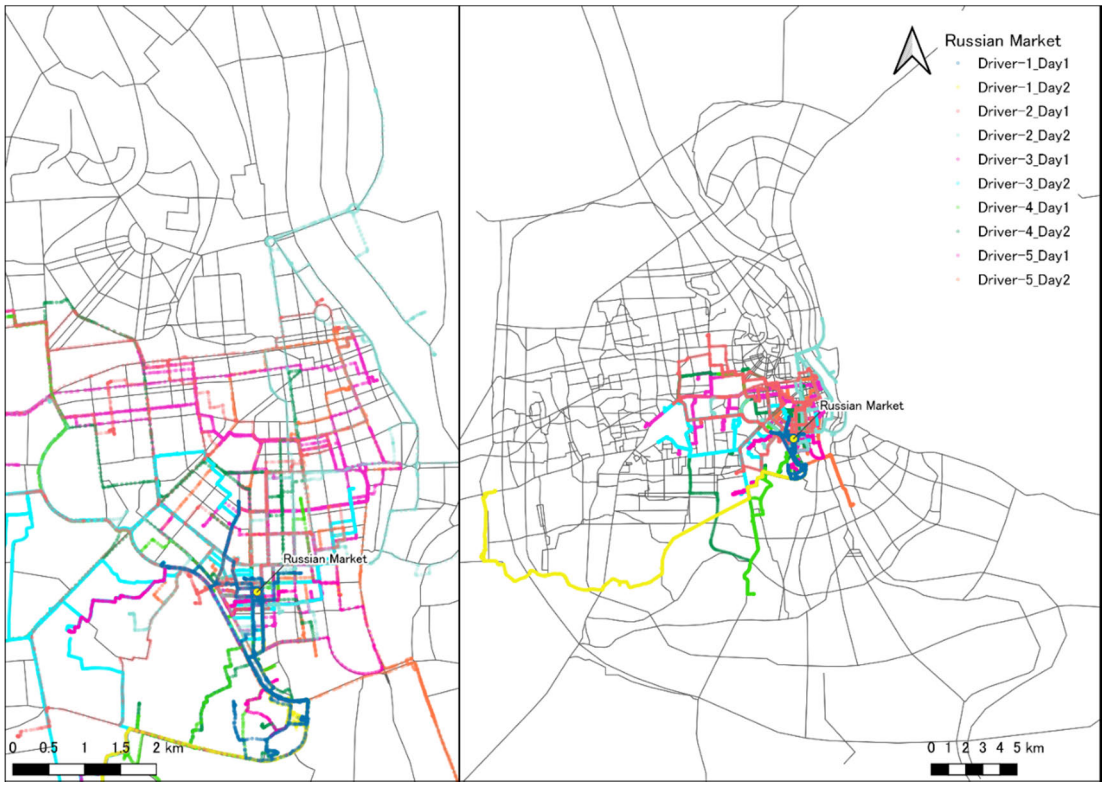
Source: JST

Figure 1.3.100 RHS Vehicle Movements (Stationed at Central Market)



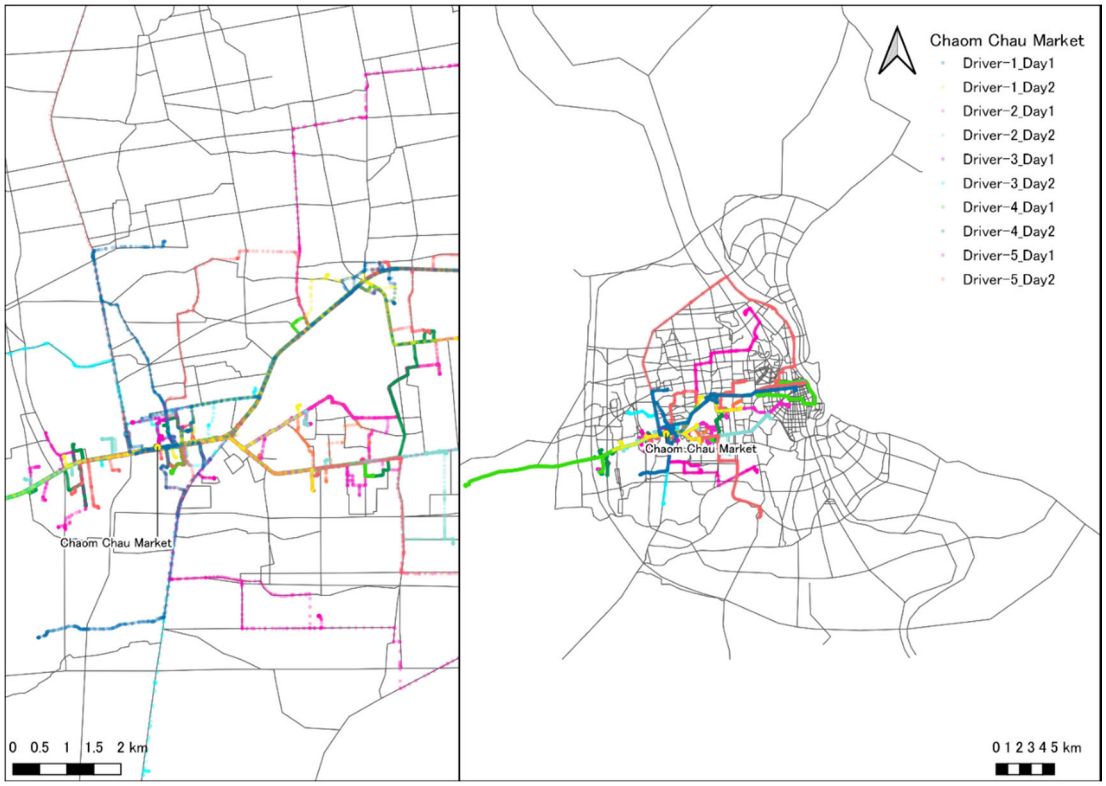
Source: JST

Figure 1.3.101 RHS Vehicle Movements (Stationed at Boeng Keng Kang)



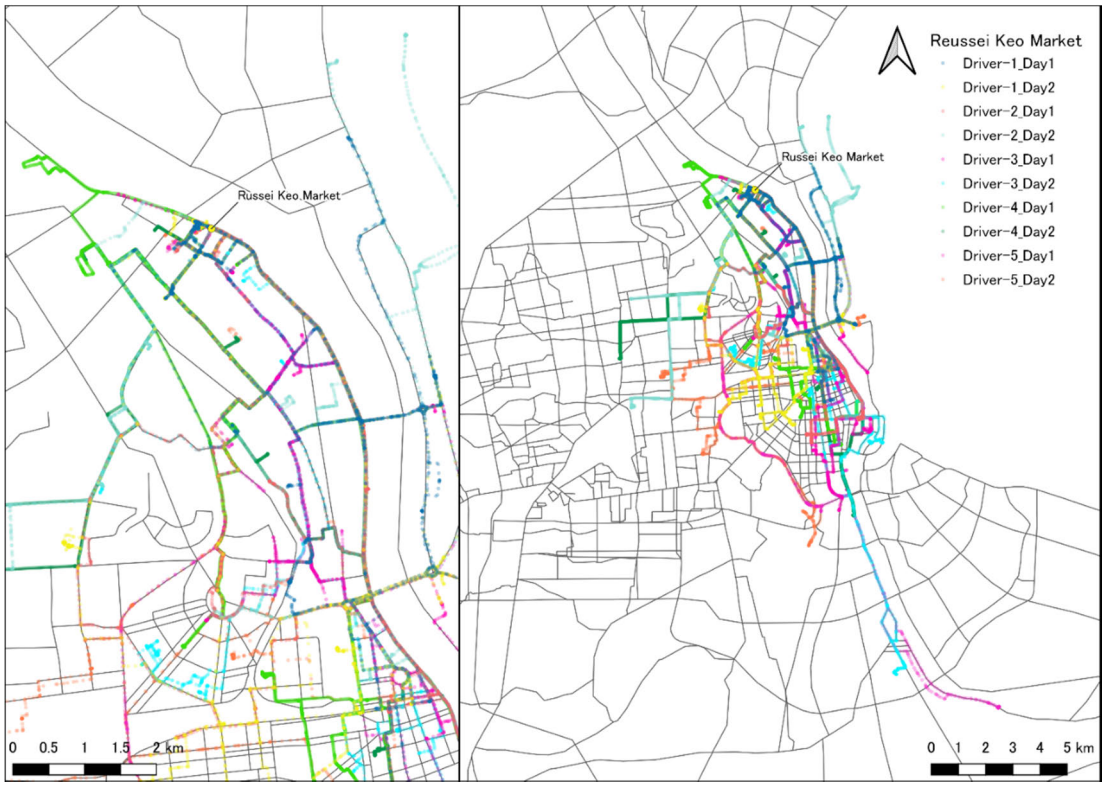
Source: JST

Figure 1.3.102 RHS Vehicle Movements (Stationed at Russian Market)



Source: JST

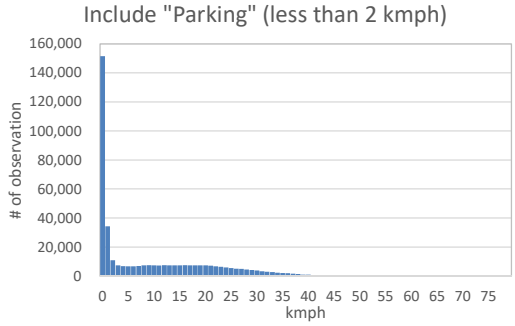
Figure 1.3.103 RHS Vehicle Movements (Stationed at Chaom Chau Market)



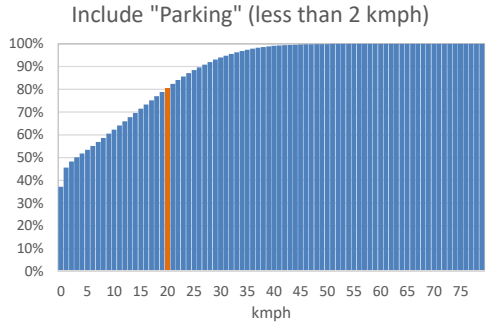
Source: JST

Figure 1.3.104 RHS Vehicle Movements (Stationed at Russei Keo Market)

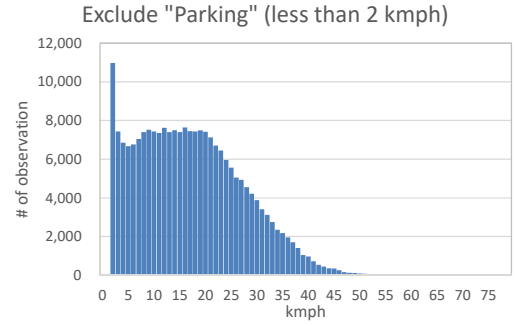
The graphs below describe the distribution of travel speed of RHS vehicles. In the case of including parking time, which is defined as less than 2 km/h, the number of observations of parking account for around 46%. In case of excluding observations of parking, around 80% of all observations are less than 26 km/h.



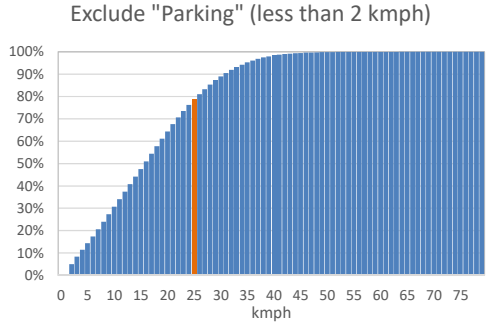
Speed Distribution (Including Parking)



Cumulative Speed Distribution (Including Parking)



Speed Distribution (Excluding Parking)

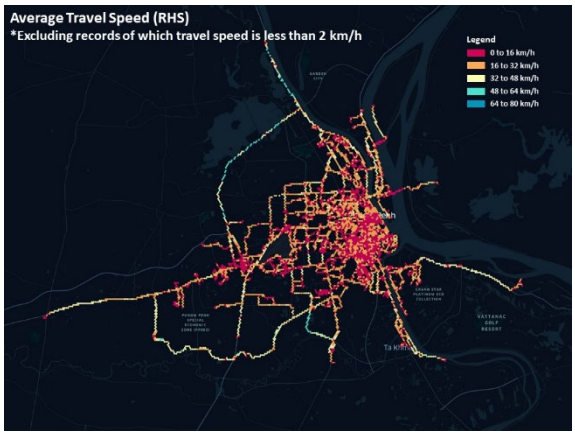


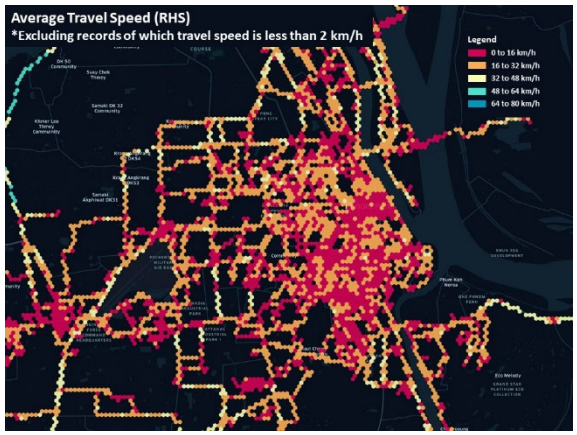
Cumulative Speed Distribution (Excluding Parking)

Note: Error records are excluded.
Note: The graphs are record basis.
Source: JST

Figure 1.3.105 Distribution of RHS Travel Speed

As shown in Figure 1.3.106, the travel speed of RHS vehicles is lower in CBD, while that of suburban areas are higher.

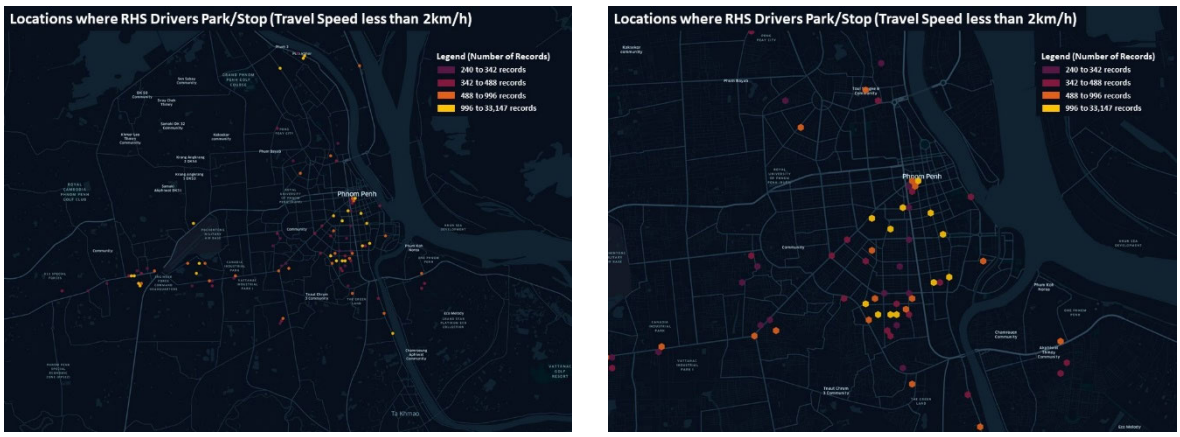




Note: Error records are excluded.
Note: Records of less than 2 km/h are regarded as parking/stopping and excluded.
Source: JST

Figure 1.3.106 Average Travel Speed of RHS

Figure 1.3.107 describes where RHS drivers park/stop their vehicles. Many stop records can be observed around Chaom Chau Market and Russei Keo Market, which suggests that it is more difficult for drivers to find passengers in suburbs.

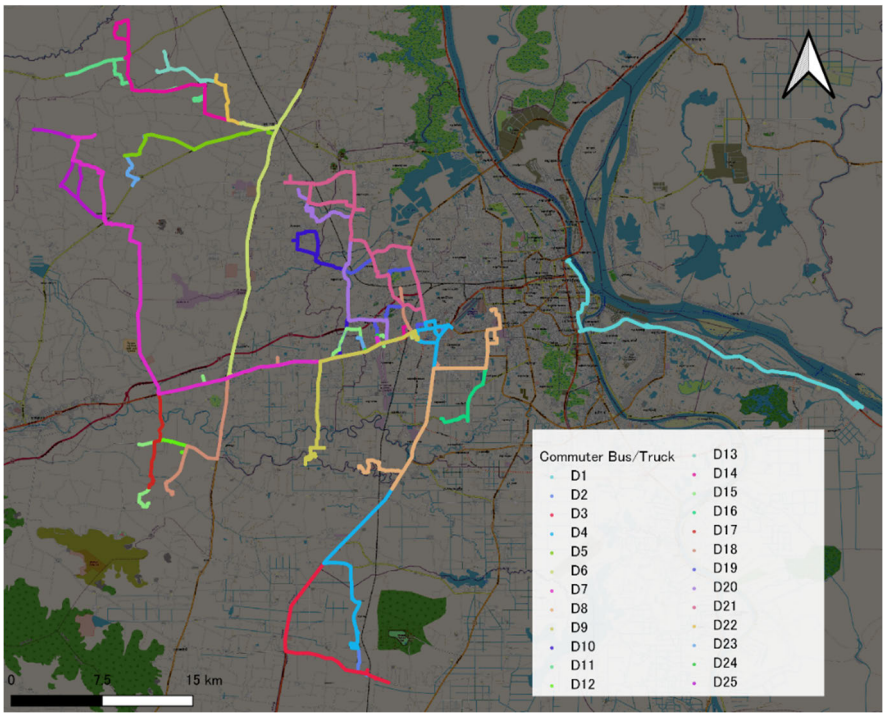


Note: Error records are excluded.
Source: JST

Figure 1.3.107 Locations where RHS Drivers Park/Stop

3) Result of Travel Speed Survey (Commuter Bus/ Truck)

Due to the influence of the COVID-19 pandemic, many companies providing commuter bus service to their employees have changed their policies. Such companies suspended the operation of private commuter services and provided employees with a commuting allowance instead. For this reason, the travel speed survey was carried out for one route of a commuter bus and 25 routes of commuter trucks. The surveyed routes and their pick-up/drop locations are described in Figure 1.3.108 and Table 1.3.41.



Note: D1 is a commuter bus route, while other routes are commuter trucks. Source: JST

Figure 1.3.108 Routes of Commuter Bus/Truck

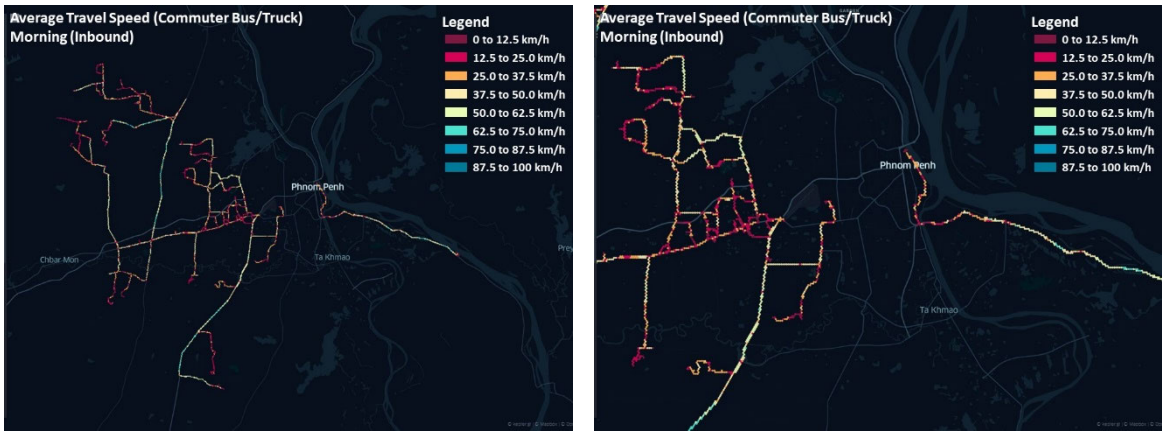
Table 1.3.41 Pick-up / Drop Locations of Commuter Bus/Truck

ID	Type	Pick-up Locations (Street/Village/Sangkat/Khan/City)	Drop Locations (Street/Village/Sangkat/Khan/City)
D1	Bus	1. Preah Sisowath Quay/Srah Chak/Daun Penh/Phnom Penh 2. Preah Norodom Blvd/Phsar Deum Thkov/Chamkar Mon/Phnom Penh 3. National Road 1/Chbar Ampov 1/Chbar Ampov/Phnom Penh 4. National Road 1/Chong Prek/Prek Eng/Chbar Ampov/Phnom Penh	1. National Road 1/Chong Prek/Prek Eng/Chbar Ampov/Phnom Penh 2. National Road 1/Chbar Ampov 1/Chbar Ampov/Phnom Penh 3. Preah Norodom Blvd/Phsar Deum Thkov/Chamkar Mon/Phnom Penh 4. Preah Sisowath Quay/Srah Chak/Daun Penh/Phnom Penh
D2	Truck	1. Phum Yol Tong / Takeo	1. Phum Yol Tong / Takeo
D3	Truck	1. Road 126 / Lumpong District / Takeo	1. Road 126 / Lumpong District / Takeo
D4	Truck	1. Phum Thmor Sor / Lumpong District / Takeo	1. Phum Thmor Sor / Lumpong District / Takeo
D5	Truck	1. Meanchey/Oudong/Kampong Speu	1. Meanchey/Oudong/Kampong Speu
D6	Truck	1. Road 51/Khsem Khsan/Oudong/Kampong Speu	1. Road 51/Khsem Khsan/Oudong/Kampong Speu
D7	Truck	1. Yuth Sameakki/Oudong/Kampong Speu	1. Yuth Sameakki/Oudong/Kampong Speu
D8	Truck	1. Deum Reus/Kandal Stueng/Kandal	1. Deum Reus/Kandal Stueng/Kandal
D9	Truck	1. Phum Boeng/Roka/Kongpisey/Kampong Speu	1. Phum Boeng/Roka/Kongpisey/Kampong Speu
D10	Truck	1. Tuol Prech/Ang Snoul/Kandal	1. Tuol Prech/Ang Snoul/Kandal
D11	Truck	1. Trach Tong/Oudong/Kampong Speu 2. Monorum/Oudong/Kampong Speu 3. Khsem Khsan/Oudong/Kampong Speu	1. Khsem Khsan/Oudong/Kampong Speu 2. Monorum/Oudong/Kampong Speu 3. Trach Tong/Oudong/Kampong Speu
D12	Truck	1. Sambour/Samraong Tong/Kampong Speu 2. Roleang Kreul / Samraong Tong/Kampong Speu 3. Stueng/Samraong Tong/Kampong Speu 4. Phum Bek Chan/Kandal	1. Phum Bek Chan/Kandal 2. Stueng/Samraong Tong/Kampong Speu 3. Roleang Kreul / Samraong Tong/Kampong Speu 4. Sambour/Samraong Tong/Kampong Speu
D13	Truck	1. Tadong/Oudong/Kampong Speu 2. Thmor Baykrem/Oudong/Kampong Speu 3. Thmei/Oudong/Kampong Speu 4. Tuol Thlong/Oudong/Kampong Speu 5. Memay/Oudong/Kampong Speu 6. Trapeang Leu/Oudong/Kampong Speu 7. Mundol/Oudong/Kampong Speu	1. Mundol/Oudong/Kampong Speu 2. Trapeang Leu/Oudong/Kampong Speu 3. Memay/Oudong/Kampong Speu 4. Tuol Thlong/Oudong/Kampong Speu 5. Thmei/Oudong/Kampong Speu 6. Thmor Baykrem/Oudong/Kampong Speu 7. Tadong/Oudong/Kampong Speu
D14	Truck	1. Tamum/Thpong/Kampong Speu 2. Torteung Tngai/Thpong/Kampong Speu 3. Veal Leu/Thpong/Kampong Speu 4. Dorng Khvit/Thpong/Kampong Speu 5. Leab Meanchey / Meanchey / Oudong / Kampong Speu 6. Road 51/Khsem Khsan/Oudong/Kampong Speu	1. Road 51/Khsem Khsan/Oudong/Kampong Speu 2. Leab Meanchey/Meanchey/Oudong/Kampong Speu 3. Dorng Khvit/Thpong/Kampong Speu 4. Veal Leu/Thpong/Kampong Speu 5. Torteung Tngai/Thpong/Kampong Speu 6. Tamum/Thpong/Kampong Speu
D15	Truck	1. Kundol Pherm/Roleang Chork/Samraong Tong/Kampong Speu	1. Kundol Pherm/Roleang Chork/Samraong Tong/Kampong Speu
D16	Truck	1. Porng Teuk/Porng Teuk/Dangkao/Phnom Penh 2. Trapeang Tea/Porng Teuk/Dangkao/Phnom Penh 3. Prey Veng/Prey Veng/Dangkao/Phnom Penh 4. Tuol Sambour/Prey Veng/Dangkao/Phnom Penh 5. Trapeang Chak/Prey Veng/Dangkao/Phnom Penh 6. Prey Sor/Prey Veng/Dangkao/Phnom Penh	1. Prey Sor/Prey Veng/Dangkao/Phnom Penh 2. Trapeang Chak/Prey Veng/Dangkao/Phnom Penh 3. Tuol Sambour/Prey Veng/Dangkao/Phnom Penh 4. Prey Veng/Prey Veng/Dangkao/Phnom Penh 5. Trapeang Tea/Porng Teuk/Dangkao/Phnom Penh 6. Porng Teuk/Porng Teuk/Dangkao/Phnom Penh
D17	Truck	1. Phum Daun Try/Roleang Kreul/Samraong Tong/Kampong Speu	1. Phum Daun Try/Roleang Kreul/Samraong Tong/Kampong Speu
D18	Truck	1. Tropeang Trav/Samraong Tong/Kampong Speu 2. Trouk Vaeng/Samraong Tong/Kampong Speu 3. Tropeang Koh/Samraong Tong/Kampong Speu 4. Tram Svay/Samraong Tong/Kampong Speu	1. Tram Svay/Samraong Tong/Kampong Speu 2. Tropeang Koh/Samraong Tong/Kampong Speu 3. Trouk Vaeng/Samraong Tong/Kampong Speu 4. Tropeang Trav/Samraong Tong/Kampong Speu

ID	Type	Pick-up Locations (Street/Village/Sangkat/Khan/City)	Drop Locations (Street/Village/Sangkat/Khan/City)
D19	Truck	1. Beng/Mkak/Ang Snoul/Kandal 2. Lomhach/Mkak/Ang Snoul/Kandal 3. Boeng Thnal/Mkak/Ang Snoul/Kandal 4. Chong Boeng/Mkak/Ang Snoul/Kandal 5. Trapeang Tnaot/Mkak/Ang Snoul/Kandal 6. Pear Rolum/Ang Snoul/Kandal 7. Moeurn Ream/Ang Snoul/Kandal	1. Moeurn Ream/Ang Snoul/Kandal 2. Pear Rolum/Ang Snoul/Kandal 3. Trapeang Tnaot/Mkak/Ang Snoul/Kandal 4. Chong Boeng/Mkak/Ang Snoul/Kandal 5. Boeng Thnal/Mkak/Ang Snoul/Kandal 6. Lomhach/Mkak/Ang Snoul/Kampong Speu 7. Beng/Mkak/Ang Snoul/Kampong Speu
D20	Truck	1. Prey Samraong/Ang Snoul/Kampong Speu 2. Peay Pork/Ang Snoul/Kampong Speu 3. Tnoat Kpous/Prek Pnov/Phnom Penh 4. Toul/Prek Pnov/Phnom Penh	1. Toul/Prek Pnov/Phnom Penh 2. Tnoat Kpous/Prek Pnov/Phnom Penh 3. Peay Pork/Ang Snoul/Kampong Speu 4. Prey Samraong/Ang Snoul/Kampong Speu
D21	Truck	1. Kan Trung/Pongsang/Praek Pnov/Phnom Penh 2. Tropang Ro Neam/Pongsang/Praek Pnov/Phnom Penh 3. Dean Chan/Pongsang/Praek Pnov/Phnom Penh	1. Dean Chan/Pongsang/Praek Pnov/Phnom Penh 2. Tropang Ro Neam/Pongsang/Praek Pnov/Phnom Penh 3. Kan Trung/Pongsang/Praek Pnov/Phnom Penh
D22	Truck	1. Ta dong/Oudong/Kampong Speu 2. TorTerng Tngai/Oudong/Kampong Speu 3. Prey TorTerng/Oudong/Kampong Speu 4. Trapeang Thmar/Oudong/Kampong Speu 5. Kandal/Oudong/Kampong Speu 6. Ank Praseth/Oudong/Kampong Speu 7. Tror Pang Toul / Kambol/ Phnom Penh	1. Tror Pang Toul / Kambol/ Phnom Penh 2. Ank Praseth/Oudong/Kampong Speu 3. Kandal/Oudong/Kampong Speu 4. Trapeang Thmar/Oudong/Kampong Speu 5. Prey TorTerng/Oudong/Kampong Speu 6. TorTerng Tngai/Oudong/Kampong Speu 7. Ta dong/Oudong/Kampong Speu
D23	Truck	1. Trapeang 7 /Chan Saen/Oudong/Kampong Speu	1. Trapeang 7 /Chan Saen/Oudong/Kampong Speu
D24	Truck	1. So Thor/Samaki/Udon/Kampong Speu 2. Roung/Samaki/Udon/Kampong Speu 3. Tapeang Tapeak/Samaki/Udon/Kampong Spe 4. Roka Keo/Samaki/Udon/Kampong Speu 5. TaYous/Samaki/Udon/Kampong Speu 6. Phsar Banteay Khmer/Cherng Rous/Udon/Kampong Speu 7. Sarang/Cherng Rous/Udon/Kampong Speu	1. Sarang/Cherng Rous/Udon/Kampong Speu 2. Phsar Banteay Khmer/Cherng Rous/Udon/Kampong Speu 3. TaYous/Samaki/Udon/Kampong Speu 4. Roka Keo/Samaki/Udon/Kampong Speu 5. Tapeang Tapeak/Samaki/Udon/Kampong Speu 6. Roung/Samaki/Udon/Kampong Speu 7. So Thor/Samaki/Udon/Kampong Speu
D25	Truck	1. Tapeang Kandal/Samaki/Udon/Kampong Speu 2. Thorma Tey/Samaki/Udon/Kampong Speu 3. Suon Nai/Samaki/Udon/Kampong Speu	1. Suon Nai/Samaki/Udon/Kampong Speu 2. Thorma Tey/Samaki/Udon/Kampong Speu 3. Tapeang Kandal/Samaki/Udon/Kampong Speu

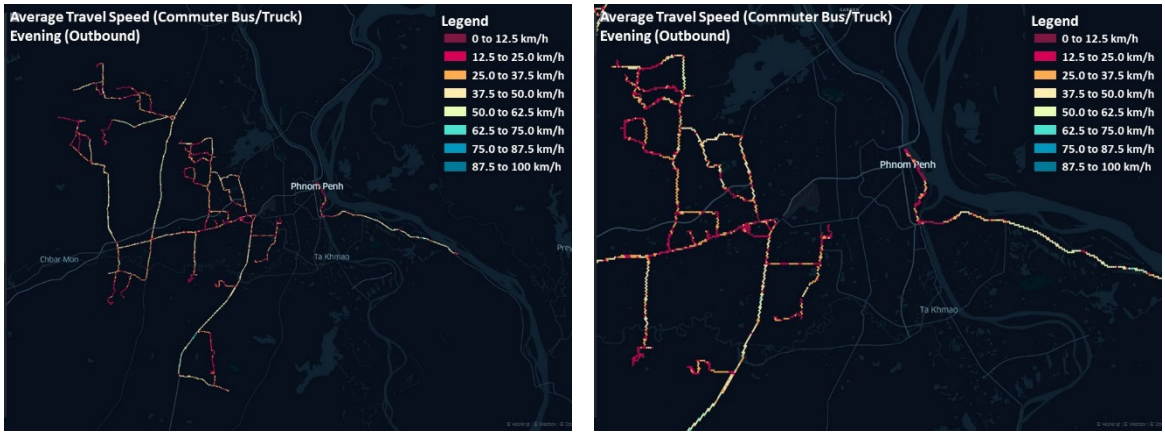
Source: JST

Figure 1.3.109 and Figure 1.3.110 show the average travel speed of the commuter bus/trucks. D1 is a commuter bus for sending commuters to Phnom Penh Autonomous Port, which travels a long distance from NR-1.



Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.109 Travel Speed of Commuter Bus/Truck (Morning, Inbound)



Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.110 Travel Speed of Commuter Bus/Truck (Evening, Outbound)

4) Result of Travel Speed Survey (City Bus)

Table 1.3.42 describes the overview of the collected City Bus GPS data. The GPS location data was collected from the City Bus routes in operation as of April 2022.

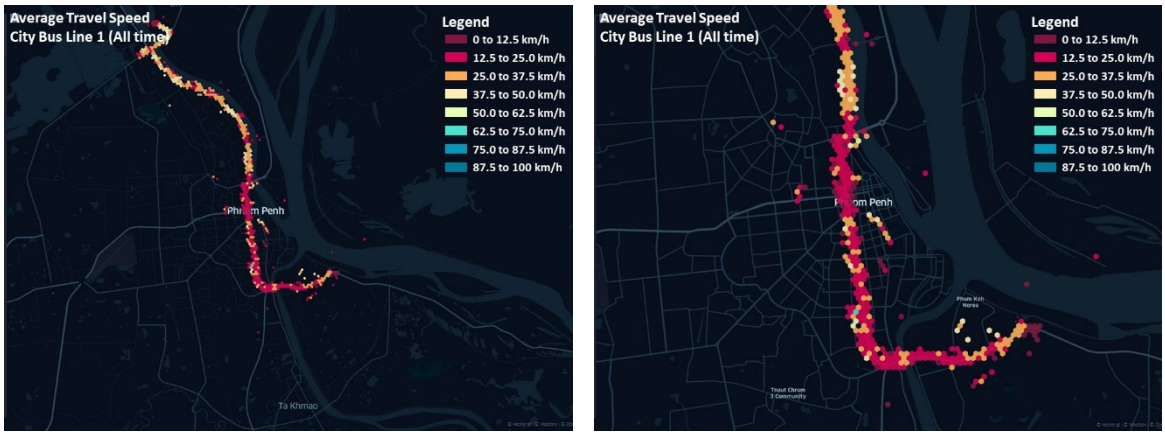
Table 1.3.42 Outline of City Bus GPS Data

Line	Record time	
	From	To
Line 1	18 April 2022 (Mon) PM	23 April 2022 (Sat) AM
Line 2	18 April 2022 (Mon) PM	23 April 2022 (Sat) AM
Line 3	18 April 2022 (Mon) PM	23 April 2022 (Sat) AM
Line 4A	18 April 2022 (Mon) PM	23 April 2022 (Sat) AM
Line 4B	18 April 2022 (Mon) PM	23 April 2022 (Sat) AM

Note: Only five lines were in operation as of April 2022.
Source: JST

Figure 1.3.111 to Figure 1.3.115 describes the average travel speed of both directions of City Bus line.

The average speed of Line 1 in CBD is slower than 25.0 km/h while the travel speed is higher in suburbs on NR-5. The similar trend can be observed in Line 2, Line 3 and Line 4A/4B. Monireth Blvd. / Veng Sreng Blvd., where Line 4A/4B pass, showed a significant drop in the average travel speed.

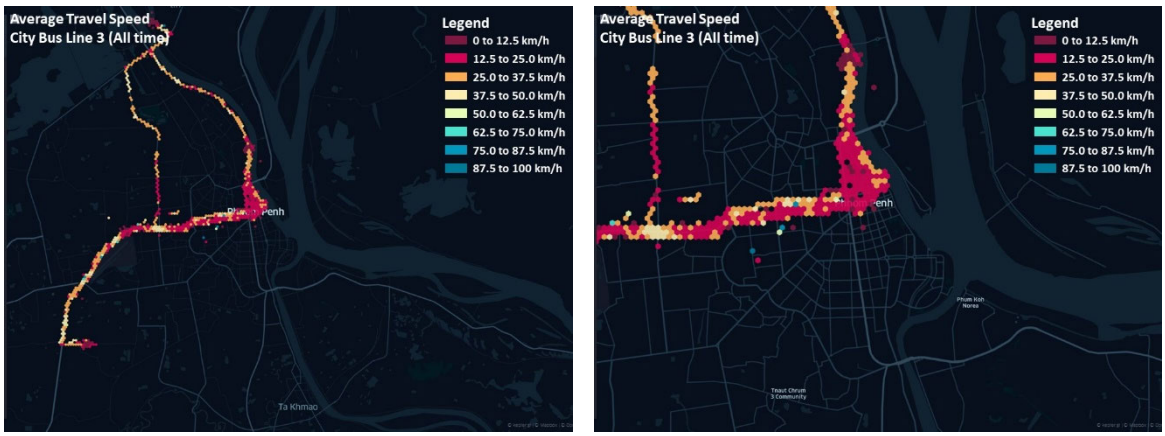


Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.111 Average Travel Speed of City Bus (Line 1) (All Time)

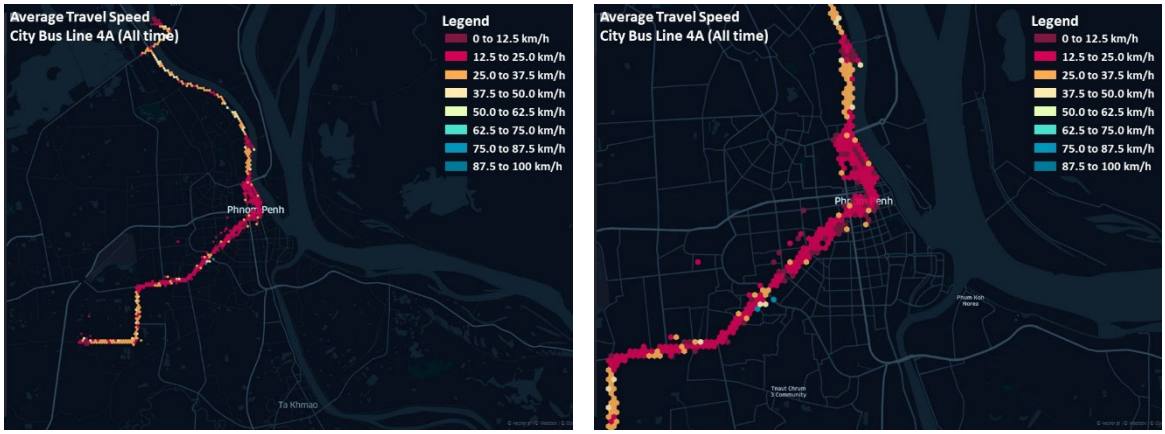
Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.112 Average Travel Speed of City Bus (Line 2) (All Time)



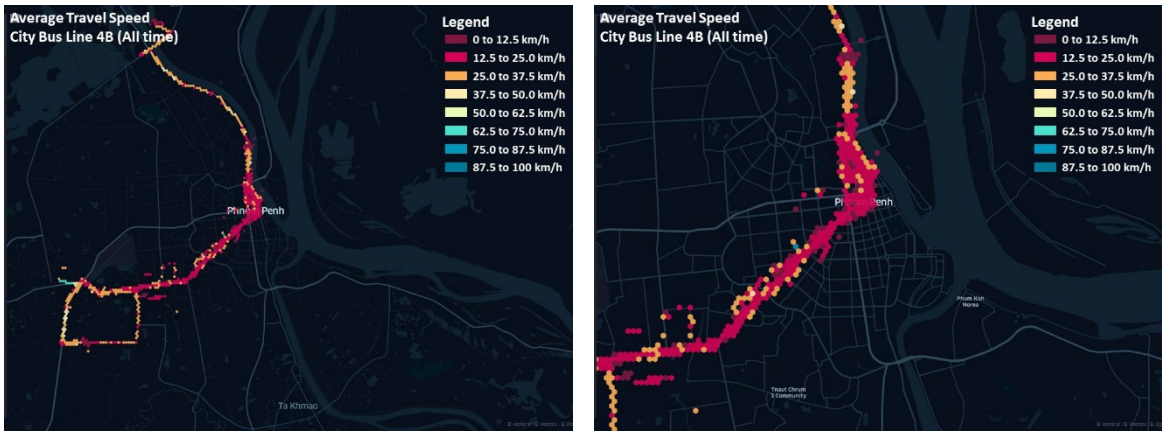
Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.113 Average Travel Speed of City Bus (Line 3) (All Time)



Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.114 Average Travel Speed of City Bus (Line 4A) (All Time)



Note: Records of which travel speed is higher than 100km/h were omitted as errors.
Source: JST

Figure 1.3.115 Average Travel Speed of City Bus (Line 4B) (All Time)

1.3.8 Parking Condition Survey (PCS)

(1) Outline

Parking Condition Survey (PCS) was conducted to obtain the current parking demand information and the parking facility and capacity information in the CBD area. The survey result is used to formulate the parking facility plan, the parking management plan and the pedestrian mall plan in the heart of the city. The survey consists of the following:

- Parking Inventory Survey;
- User Counting Survey; and
- User Interview Survey

(2) Survey Coverage

1) General

a) Survey Method and Survey Days

The Parking Condition Survey was conducted on weekdays from Tuesday to Thursday (excluding holidays). The survey time was covered from 6:00 in the morning until 22:00 at night time.

b) Survey Locations

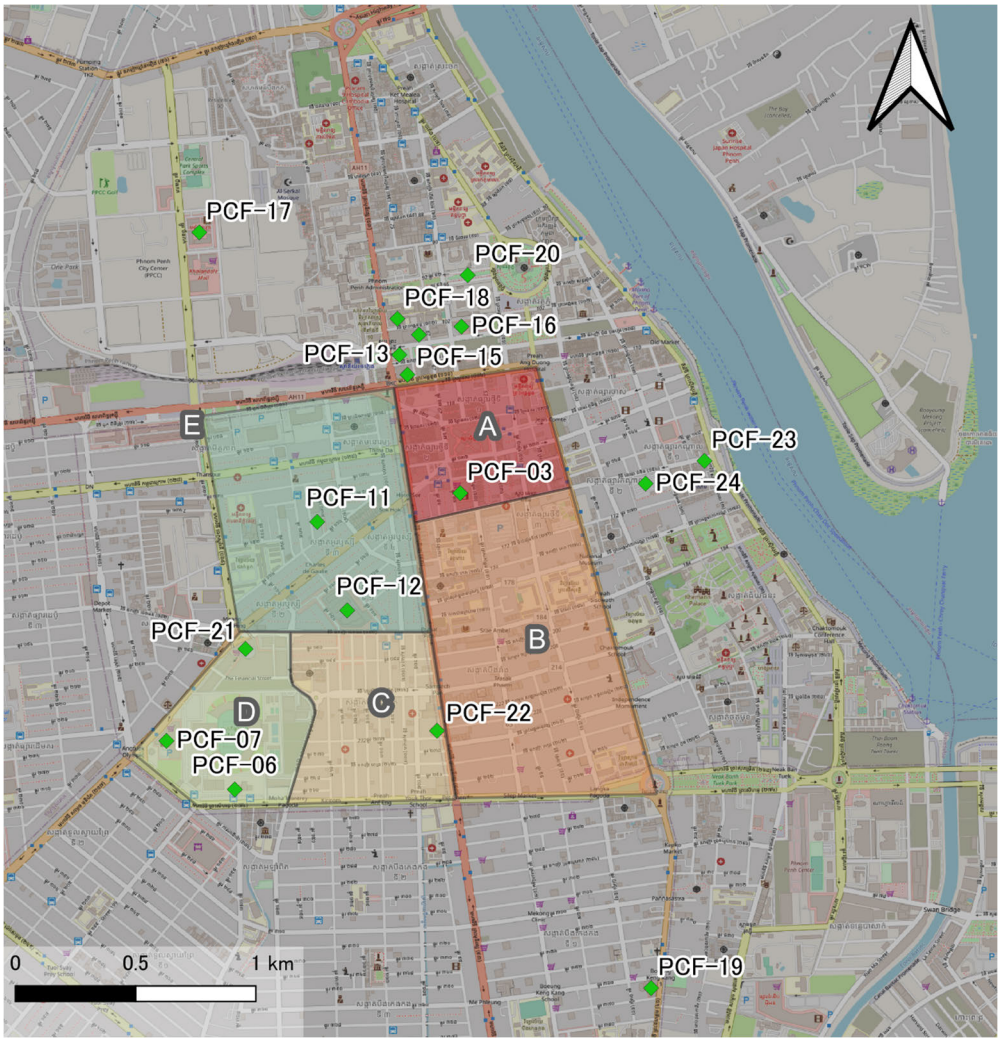
The survey area was divided into five blocks, which contained two types of locations, namely 17 parking facilities (Table 1.3.43 and Figure 1.3.116) and 38 street sections (Table 1.3.44 and Figure 1.3.117).

Table 1.3.43 Survey Locations (Parking Facilities) (Off-street)

#	Location ID*	Parking Facility	Parking Type	Block
1	PCF-3	Sorya Shopping Center	At grade	A
2	PCF-6	Underground Parking	Underground	D
3	PCF-7	City Mall	At grade and underground	D
4	PCF-11	Serey Pheap	At grade	E
5	PCF-12	Ou Russei Market	At grade	E
6	PCF-13	Underground Parking of Former Buddha Stupa	Underground	N/A
7	PCF-14	Vattanac Capital	At grade and underground	N/A
8	PCF-15	Canadia Tower	At grade	N/A
9	PCF-16	Exchange Square	At grade	N/A
10	PCF-17	Eden Garden	At grade	N/A
11	PCF-18	Secure Parking	At grade	N/A
12	PCF-19	Noromall	Underground	N/A
13	PCF-20	MEF Parking	Underground	N/A
14	PCF-21	Olympia	Underground	D
15	PCF-22	Phnom Penh Tower	At grade and underground	C
16	PCF-23	Wat Outnaloam	At grade	N/A
17	PCF-24	Parking Near Wat Outnaloam	At grade	N/A

Note: The location ID corresponds to the IDs used in the 2012 survey. Missing ID indicates the location where the parking space does not exist as of 2022.

Source: JST



Note: A to E indicate Blocks in CBD.
Source: JST

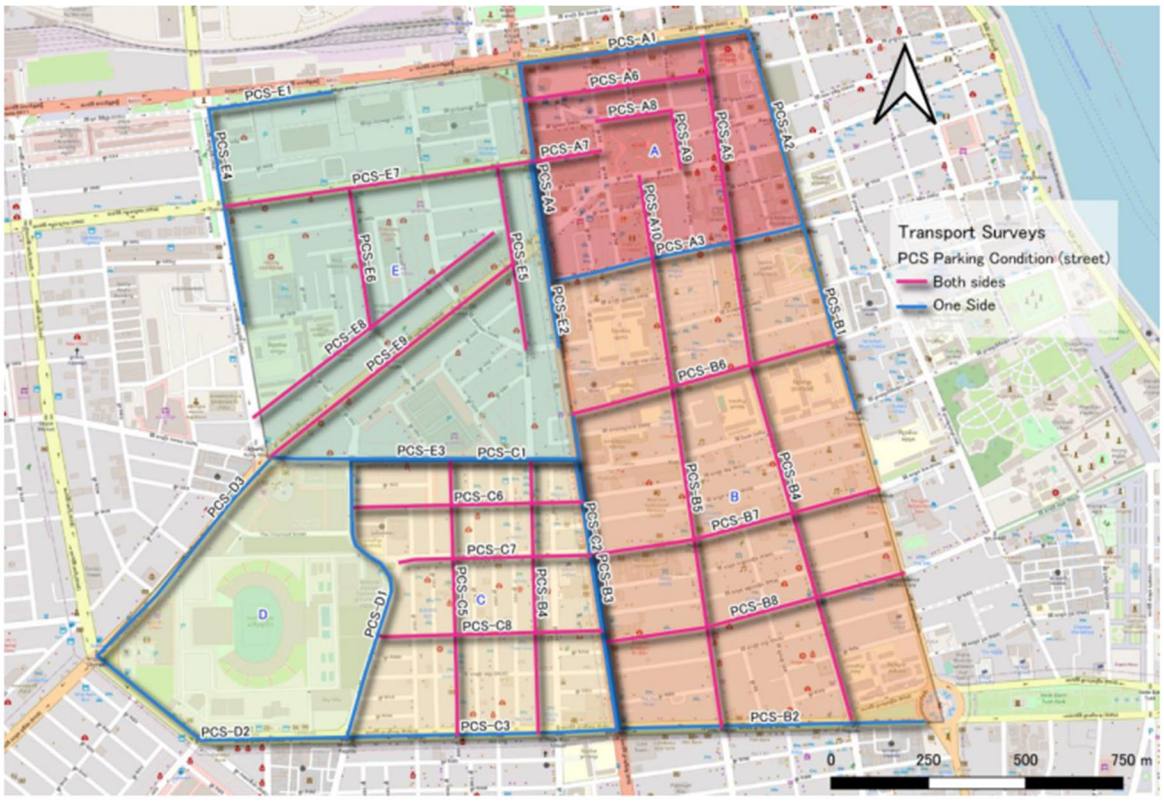
Figure 1.3.116 Survey Locations (Parking Facilities) (Off-street)

Table 1.3.44 Parking Survey Locations (On-street)

Block	No.	Street Name	Side	ID
A	1	Russian (Rd 110)	One	PCS-A1
	2	Norodom	One	PCS-A2
	3	Rd 154	One	PCS-A3
	4	Monivong (Rd 93)	One	PCS-A4
	5	Rd 51	Both	PCS-A5
	6	Rd 118	Both	PCS-A6
	7	Kampuchea Krom (Rd 128)	Both	PCS-A7
	8	Central Market (North)	Both	PCS-A8
	9	Central Market (East)	Both	PCS-A9
	10	Rd 63	Both	PCS-A10
B	1	Norodom	One	PCS-B1
	2	Sihanouk (Rd 274)	One	PCS-B2
	3	Monivong (Rd 93)	One	PCS-B3
	4	Rd 51	Both	PCS-B4
	5	Rd 63	Both	PCS-B5
	6	Rd 178	Both	PCS-B6
	7	Rd 214	Both	PCS-B7
	8	Rd 240	Both	PCS-B8

Block	No.	Street Name	Side	ID
C	1	Rd 182	One	PCS-C1
	2	Monivong (Rd 93)	Both	PCS-C2
	3	Sihanouk (Rd 274)	Both	PCS-C3
	4	Rd 107	Both	PCS-C4
	5	125	Both	PCS-C5
	6	198	Both	PCS-C6
	7	214	One	PCS-C7
	8	232	Both	PCS-C8
D	1	Rd 161-163	Both	PCS-D1
	2	Sihanouk	Both	PCS-D2
	3	Monireth	Both	PCS-D3
E	1	Russian (Rd 110)	Both	PCS-E1
	2	Monivong (Rd 93)	Both	PCS-E2
	3	Rd 184	One	PCS-E3
	4	Tchecoslovaquie (Rd 169)	One	PCS-E4
	5	Rd 107	One	PCS-E5
	6	Rd 139	Both	PCS-E6
	7	Kampuchea Krom (Rd 128)	Both	PCS-E7
	8	Rd 164	Both	PCS-E8
	9	Charles de Gaulle (Rd 217)	Both	PCS-E9

Source: JST



Source: JST

Figure 1.3.117 Survey Locations (On-street)

c) Definition of Legal and Illegal Parking (On-street)

The definition of legal and illegal parking for on-street parking employed in the survey are described in Table 1.3.45. Furthermore, the target of each survey content is summarised in Table 1.3.46.

Table 1.3.45 Definition of Legal and Illegal Parking (On-street)

Type	Description	Sample Photo
Legal-1 (L-1)	L-1: a parking inventory providing legal parking space for motorbikes and other vehicles with red/white/yellow line marking and parking fee. (e.g. Central Market and City Mall on-street parking)	
Legal-2 (L-2)	L-2: a parking inventory providing legal parking space for motorcycles and vehicles with red/white/yellow line marking and option to pay for parking fee (e.g. mart, shop, gas station, and bank parking space)	
Illegal-1 (I-1)	I-1: a parking on streets that provides an illegal parking space for motorbikes and vehicles without any cross-line marking and causes inconveniences to the public or traffic congestion on streets.	

Source: JST

Table 1.3.46 Target Parking Type for Parking Condition Survey

Type of Parking		Parking Condition Survey		
		Parking Inventory Survey	User Counting Survey	User Interview Survey
Off-street (PCF)	Parking Facility	Surveyed	Surveyed	Surveyed
On-street (PCS)	Legal Parking 1 (L-1)	Surveyed	Surveyed	Surveyed
	Legal Parking 2 (L-2)	Not Surveyed	Surveyed	Surveyed
	Illegal Parking (I-1)	Not Surveyed	Surveyed	Surveyed

Source: JST

2) Parking Inventory Survey

a) Survey Items

The Parking Inventory Survey was conducted to understand parking facilities in the survey area which is located in the CBD.

The survey items are as follows:

- Location of parking facility
- Number of parking spaces
- Type of parking
- Operation hours
- Parking fee (with ticket / without ticket)
- Type of ownership, such us municipal parking, private or restricted to employees or customers of a particular building
- Number of in/out vehicles

3) User Counting Survey

a) Survey Items

Survey items for the user counting survey are shown as follows:

- Number of parked vehicles by types at the beginning of every time unit (legal or illegal),
- Number of entering and leaving vehicles types for every time unit, and

4) User Interview Survey

a) Survey Items

The following items were included in the interview with the parking users;

- Purpose of parking,
- Origin of the trip,
- Number of passengers,
- Parking time and duration,
- Frequencies of using parking facility,
- Possibility of using alternative transportation mode with park and ride system,
- Stated preference on parking area management charge,
- Distance to the destination from the parking, and
- Any problems and requests on parking facilities.

b) Target Sample

The User Interview Survey was conducted at off-street parking facilities (PCF) and on-street parking (PCS). The sample rate of the survey from each block and each facility to be interviewed should exceed 20 percent of entering and leaving vehicles in every hour.

(3) Results of Parking Inventory Survey

1) Off-street Parking Facility (PCF)

Table 1.3.47 describes the result of Parking Inventory Survey for off-street parking facility (PCF). The major findings are as follows.

- In the all blocks, the total number of parking spaces for motorbikes is about 15,000, while that of passenger cars is about 4,800.

- 11 out of 17 parking facilities are open for 24 hours.
- The parking fee is KHR 1,000 per time for a motorbike in 7 of 17 facilities.
- Some locations are free of charge as most users are employees of tenants which the parking facility belongs to.

Table 1.3.47 Result of Parking Inventory Survey (Off-street Parking Facility: PCF)

ID	Name of Parking Facility	Type of Parking	Number of Parking Spaces		Operation hours	Parking Fees (KHR/time)		Night Time (after 22:00)	Type of Ownership
		1. At grade 2. Underground 3. Multiple	Motorbike	Passenger Car		Motorbike	Passenger Car	1. Open 2. Closed	1. Public 2. Private 3. Company 4. Others
PCF-3	Sorya Shopping Center	3	114	219	24	1,000	1,000 KHR/hr	1	2
PCF-6	Underground Parking	2	120	208	24	1,000	*6,833 KHR/day	1	2
PCF-7	City Mall	3	2,000	150	18	500	1,000 KHR/hr	1	2
PCF-11	Serey Pheap Market	1	35	75	24	1,000	*6,833 KHR/day	1	2
PCF-12	Ou Russei Market	3	1,880	300	24	500	1,000 KHR/hr	1&2	1&2
PCF-13	Underground Parking Former Buddha Stupa	2	1,390	204	14	0	0	2	2
PCF-14	Vattanac Capital	2	570	281	24	0	0	1	2
PCF-15	Canadia Tower	2	90	141	24	0	0	1	3
PCF-16	Exchange Square	1&2	300	468	24	1,500	1,000 KHR/hr	1&2	2
PCF-17	Eden Garden	1	800	209	24	1,000	2,000 KHR/hr	2	2
PCF-18	Secure Parking	1&2	650	198	16	500	1,000 KHR/hr	1	2
PCF-19	Noro Mall	3	382	50	18	1,000	2,000 KHR/hr	1	2
PCF-20	MEF	2	220	315	12	0	0	2	1
PCF-21	Olympia Mall	2	4,500	1,500	24	1,000	1,000 KHR/hr	1	2
PCF-22	Phnom Penh Tower	1&2	800	118	24	500	2,000 KHR/hr	1	2
PCF-23	Wat Ounalom	1	0	23	24	0	0	1	1
PCF-24	Parking Near Wat Ounalom	1	1,000	300	24	1,000	5,000 KHR/day	1	2
Total			**14,851**	**4,759**					

*Note: Fee in USD/month was converted to KHR/month with the rate of 4100 KHR/USD and then further converted to KHR/day assuming that one month has 30 days.

Source: JST

2) On-street Legal Parking 1 (PCS L-1)

Table 1.3.48 illustrates a summary of the results of the parking inventory survey of on-street legal parking 1 (PCS L-1), which were found in Block A and D only.

Table 1.3.48 Result of Parking Inventory Survey (On-street Legal Parking 1: PCS L-1)

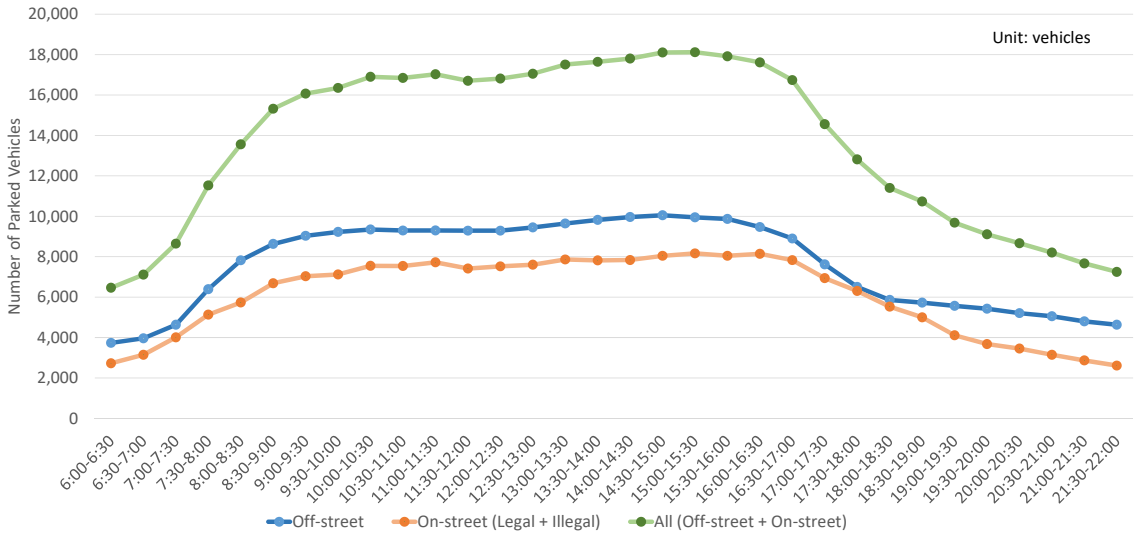
Block	Name of Parking Facility	Type of Parking	Number of Parking Spaces		Operation hours	Parking Fees (time/KHR)		Open after 22:00	Type of Ownership
		1. At grade 2. Underground 3. Multiple	MC	Car		MC	Car	1. Open 2. Closed	1. Public 2. Private 3. Company 4. Others
A	Share Taxi to Province	1	0	15	24	0	3,500 KHR/day	1	2
A	Central Market	1	150	30	12	1,000	0	2	1
A	Central Market	1	150	30	12	1,000	0	2	1
D	City Mall	1	390	18	12	1,500	2,000 KHR/day	2	2
Total			**690**	**93**					

Source: JST

(4) Results of User Counting Survey

1) Parking Demand

Figure 1.3.118 describes the result of the user counting survey for off-street parking facilities (PCF) and on-street parking (PCS L-1, L-2 and I-1). The result suggests that the parking demand remains high during daytime and drops to less than the half at night time.

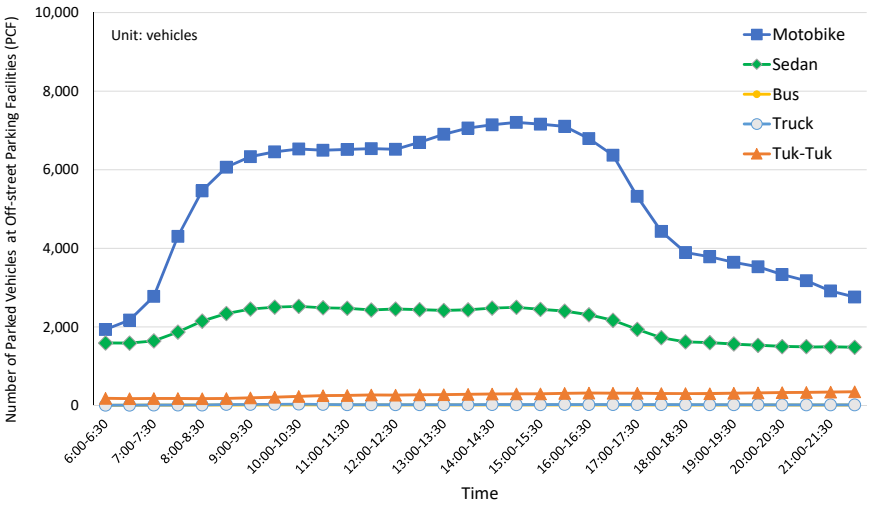


Note: The data was collected through user counting survey.
Note1: Off-street parking indicates "PCF". Locations outside Block A to E are included as well.
Note2: On-street parking (legal) includes "PCS L-1" and "PCS L-2" in Block A to E.
Note3: On-street parking (illegal) indicates "PCS I-1" in Block A to E.
Source: JST

Figure 1.3.118 Parking Demand (Off-street and On-street)

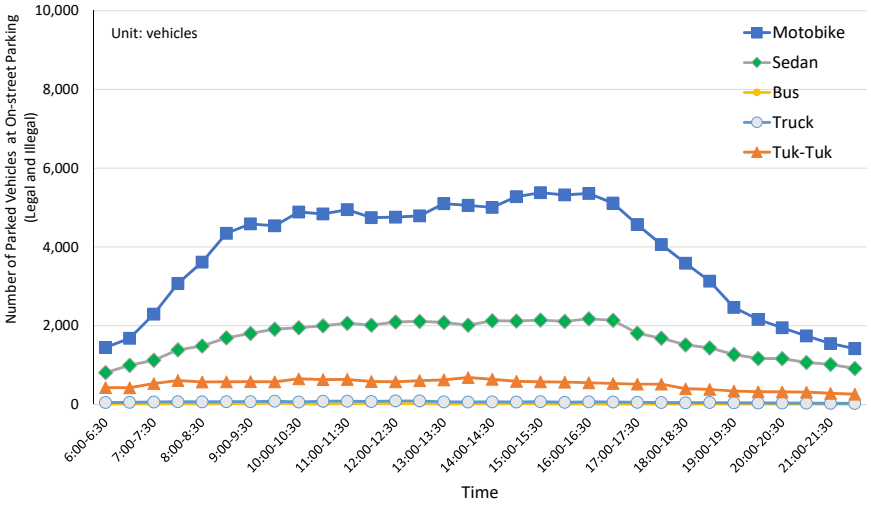
2) Parking Demand by Vehicle Modes

The following figures describe the parking demand by vehicle types at off-street parking facilities (PCF) and legal/illegal on-street parking (PCS L-1, L-2 and I-1) respectively. The parking demand of motorcycles is dominant at both off-street parking and on-street parking.



Note: The data was collected through user counting survey.
Note: Off-street parking indicates "PCF". Locations outside Block A to E are included as well.
Source: JST

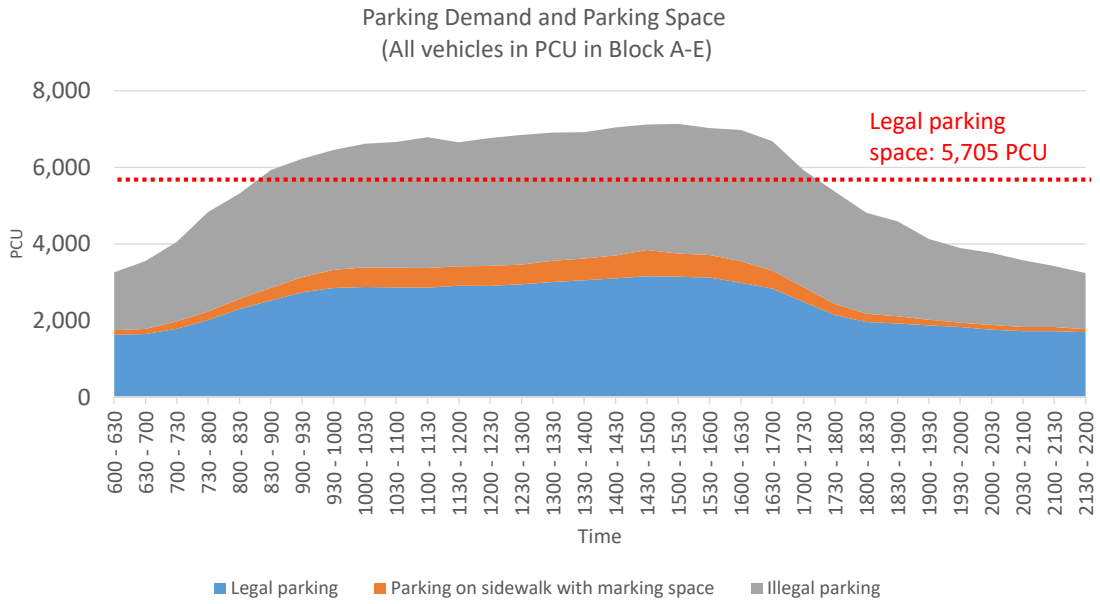
Figure 1.3.119 Parking Demand by Vehicle Mode (Off-street)



Note: On-street parking includes "PCS L-1", "PCS L-2" and "PCS I-1" in Block A to E.
Source: JST

Figure 1.3.120 Parking Demand by Vehicle Mode (On-street)

Parking capacity in Block A to E was still under the parking demand during daytime as shown in Table 1.3.17.

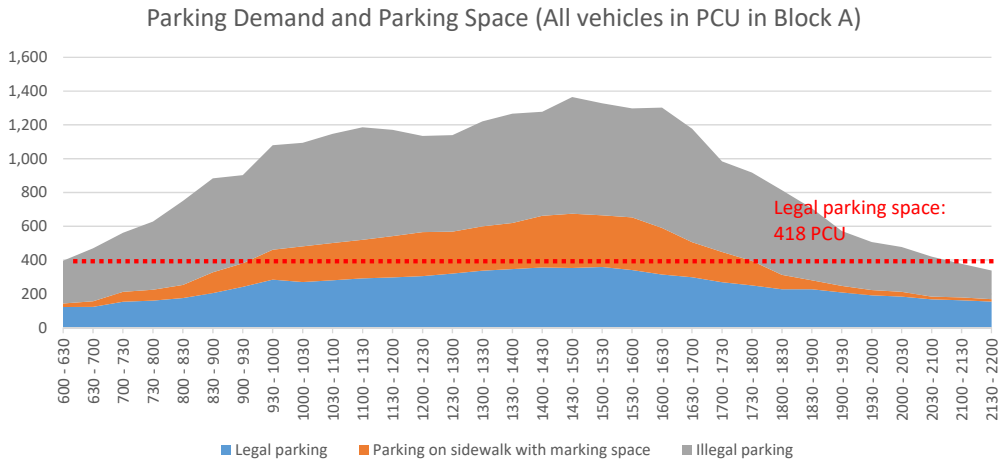


Source: JST

Figure 1.3.121 Comparison between Parking Demand and Parking Capacity (Block A-E)

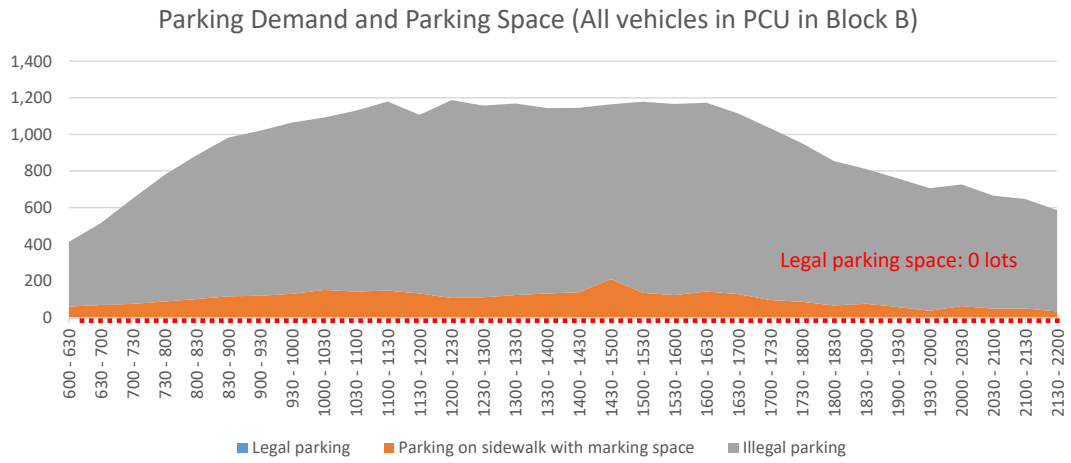
3) Parking Demand by Block

Figure 1.3.122 to Figure 1.3.126 illustrate the comparison between parking demand and parking capacity for all vehicle types by block.



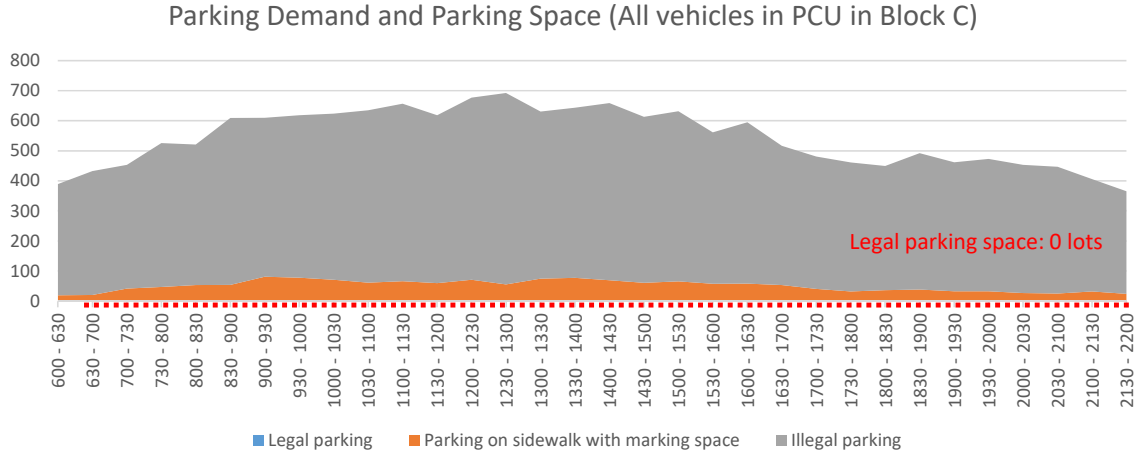
Source: JST

Figure 1.3.122 On-street and Off-street Parking Demand by Block (All Vehicles in Block A)



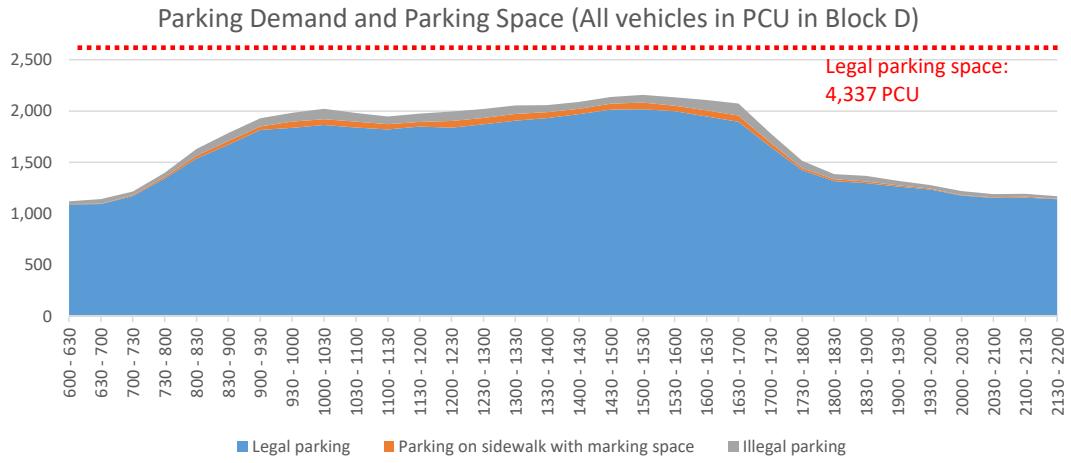
Source: JST

Figure 1.3.123 On-street and Off-street Parking Demand by Block (All Vehicles in Block B)



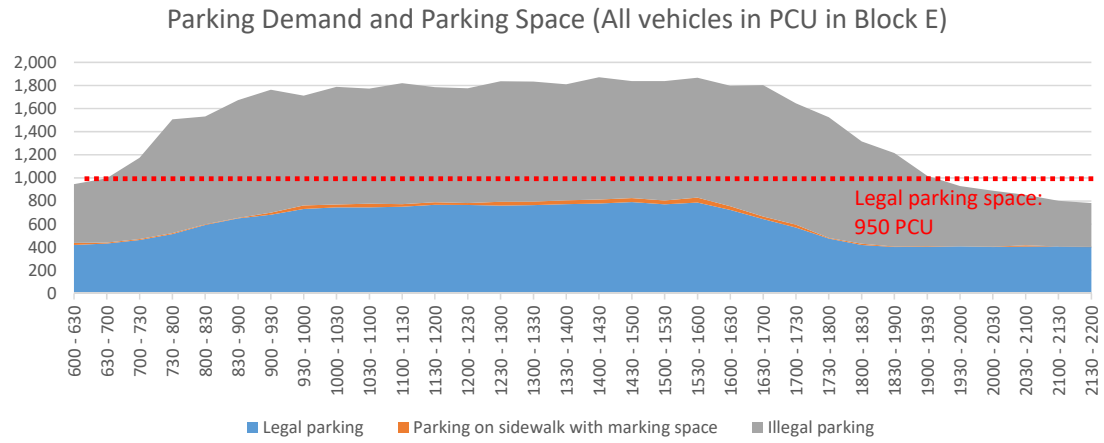
Source: JST

Figure 1.3.124 On-street and Off-street Parking Demand by Block (All Vehicles in Block C)



Source: JST

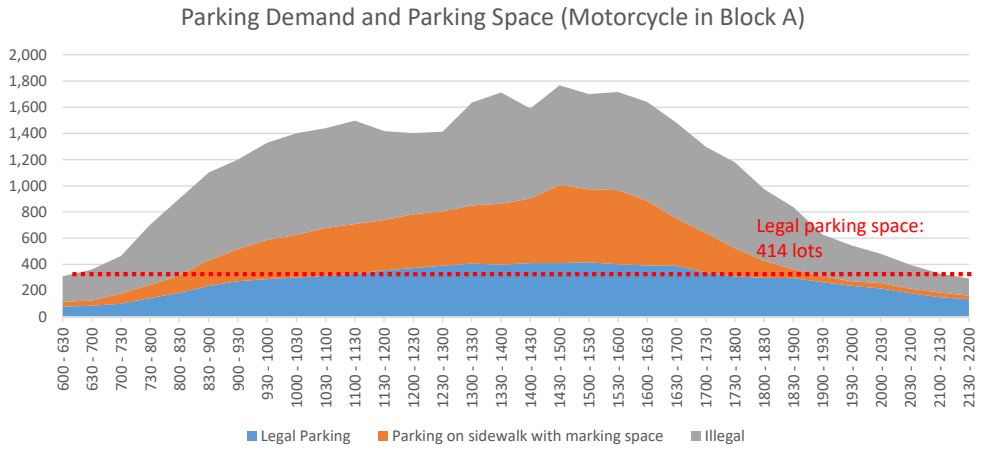
Figure 1.3.125 On-street and Off-street Parking Demand by Block (All Vehicles in Block D)



Source: JST

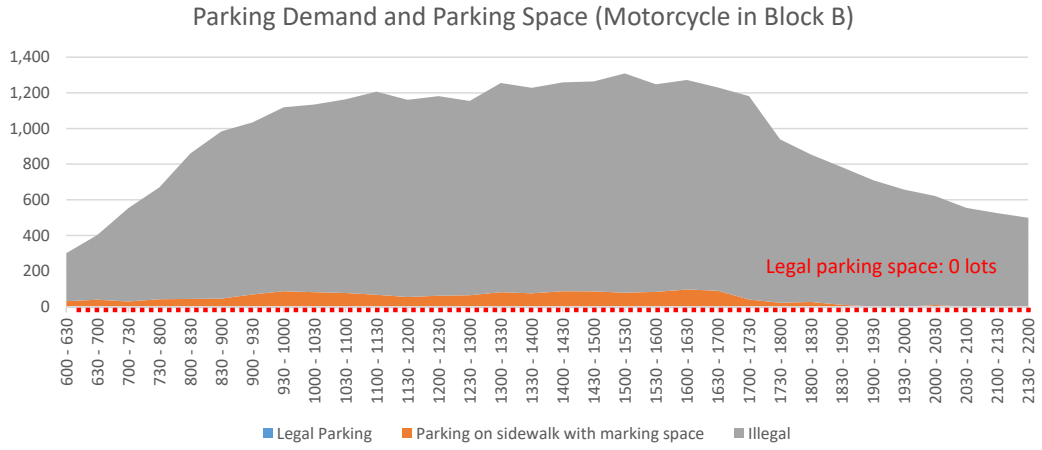
Figure 1.3.126 On-street and Off-street Parking Demand by Block (All Vehicles in Block E)

Figure 1.3.127 to Figure 1.3.131 illustrate the comparison between parking demand and parking capacity for motorbikes by block.



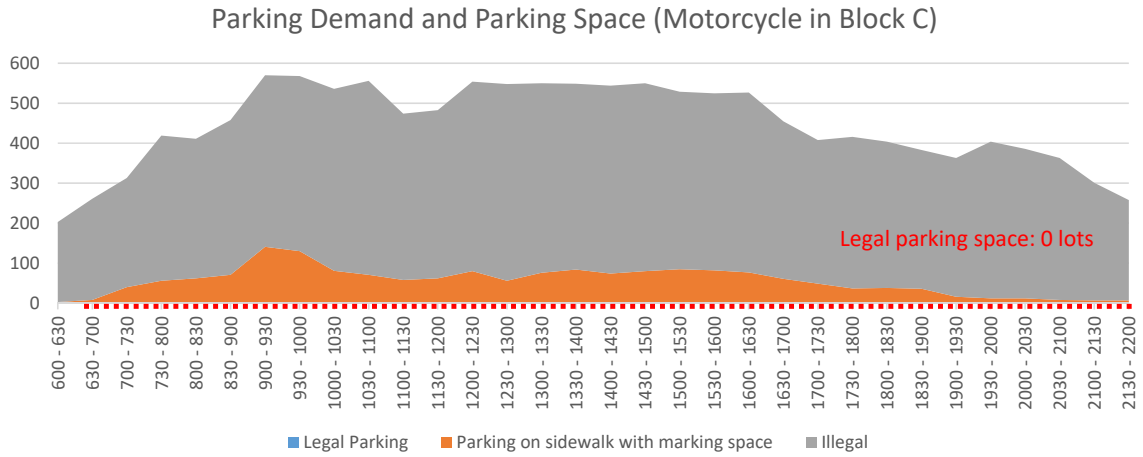
Source: JST

Figure 1.3.127 On-street and Off-street Parking Demand by Block (Motorcycle in Block A)



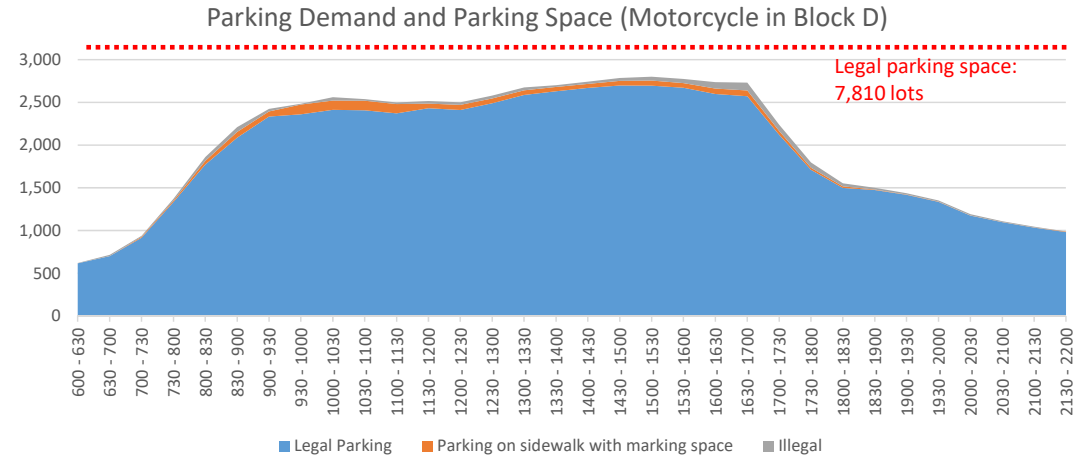
Source: JST

Figure 1.3.128 On-street and Off-street Parking Demand by Block (Motorcycle in Block B)



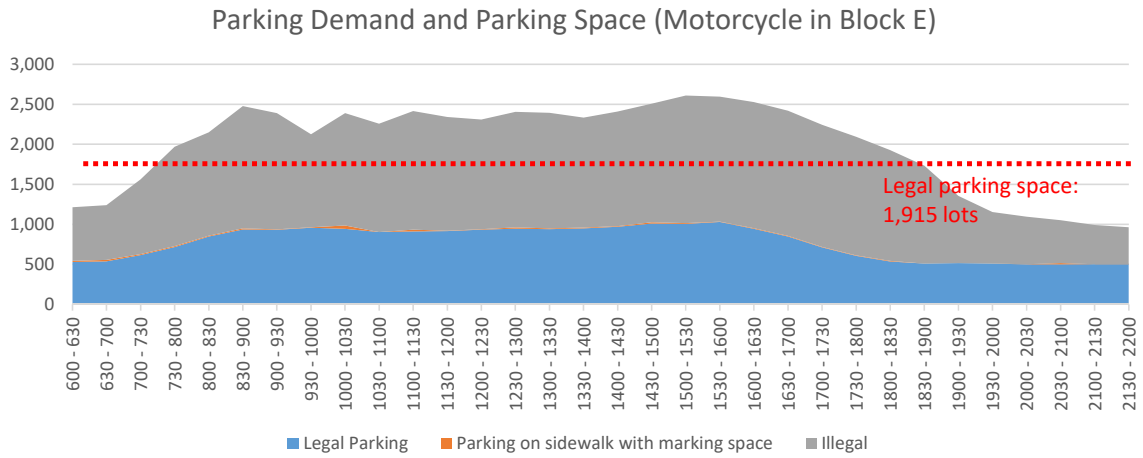
Source: JST

Figure 1.3.129 On-street and Off-street Parking Demand by Block (Motorcycle in Block C)



Source: JST

Figure 1.3.130 On-street and Off-street Parking Demand by Block (Motorcycle in Block D)

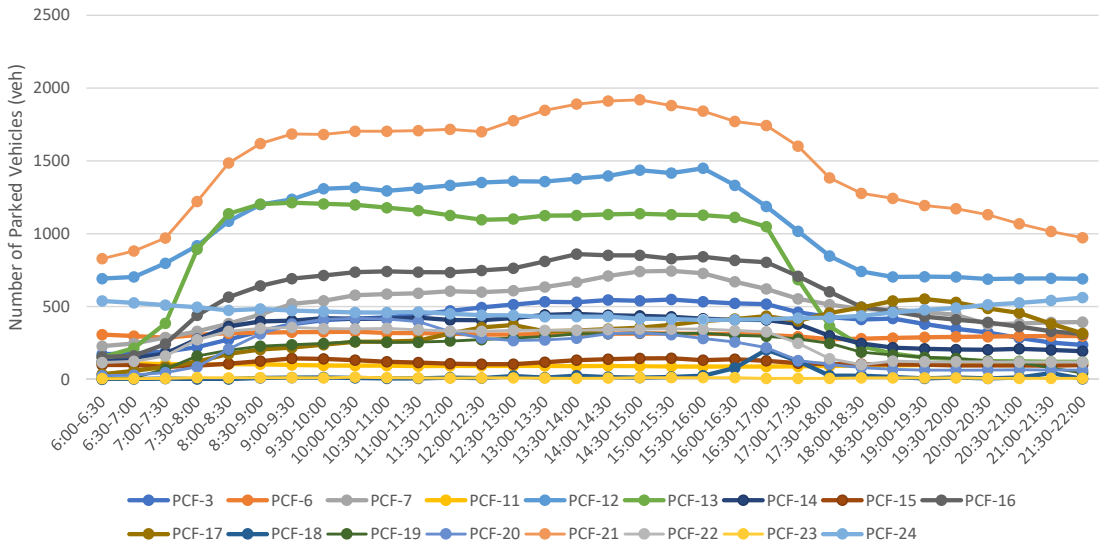


Source: JST

Figure 1.3.131 On-street and Off-street Parking Demand by Block (Motorcycle in Block E)

4) Parking Demand by Facility

Figure 1.3.132 describes the parking demand by facility. Mostly the peak time of parking demand is during the daytime at any parking facility.

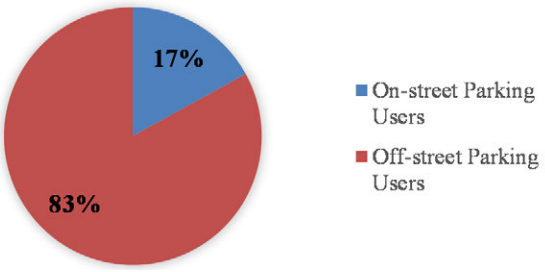


Unit: vehicle
Source: JST

Figure 1.3.132 Parking Facility Demand Fluctuation (All Vehicle)

(5) Result of User Interview Survey

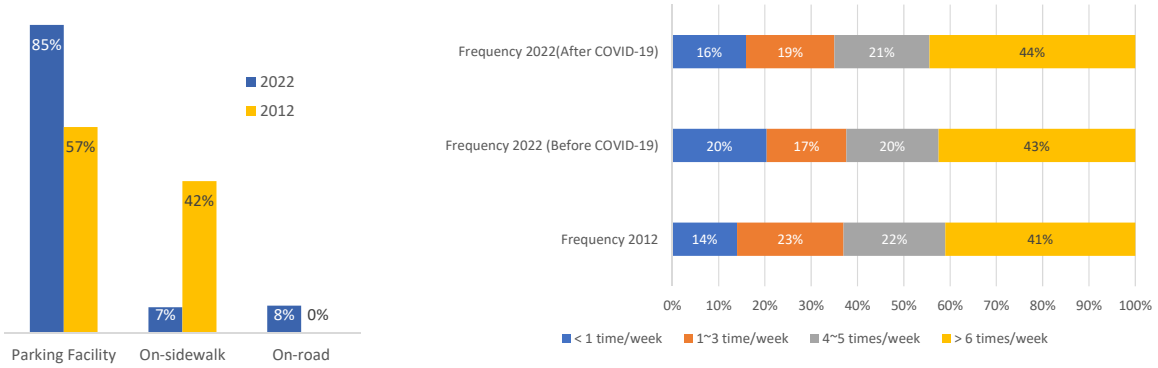
The results of the User Interview Survey regarding vehicle composition, frequency of parking, parking location, trip purpose, parking distance, parking fee, etc., are described in this section. The samples were collected from on-street parking users and off-street parking users of which distribution is illustrated in Figure 1.3.133.



Source: JST

Figure 1.3.133 Distribution of User Interview Survey Respondents

85% of respondents parked their vehicles at parking facilities while only 8% parked on the road and 7% parked on the sidewalk (See Figure 1.3.134). However, these figures may have been influenced by the selection of respondents in each parking facility. The frequency of parking slightly increased from 2012 even after the COVID-19 pandemic.

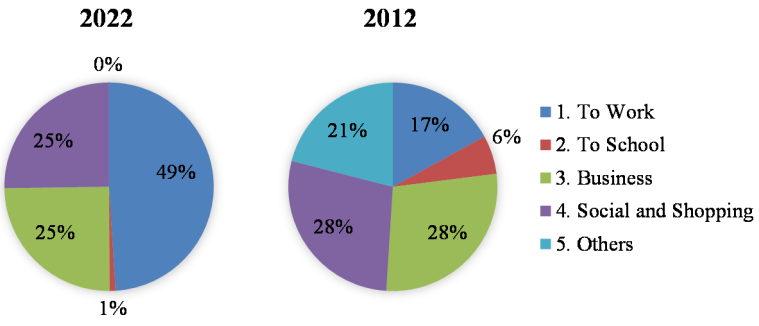


Location where Respondents Parked　　Frequency of Using this Parking

Source: JST

Figure 1.3.134　Location of Parking and Use Frequency

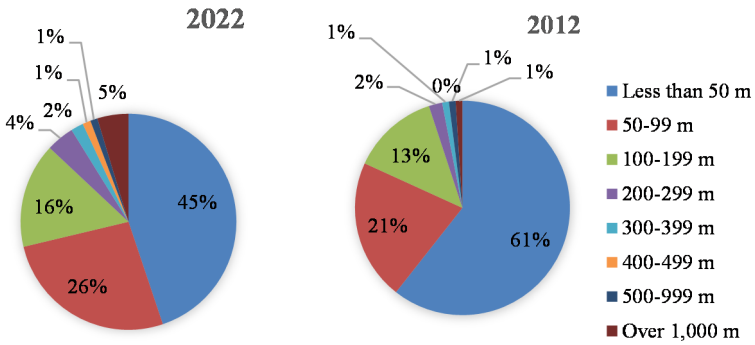
Figure 1.3.135 shows that 49% of trip purpose was "To work" followed by "Business" and "Social and Shopping" at 25% each while "To School" accounted for only 1%. Compared to 2012, the proportions of "To Work" trip increased dramatically and those of other trip purposes decreased accordingly.



Source: JST

Figure 1.3.135　Comparison of Trip Purposes between 2022 and 2012

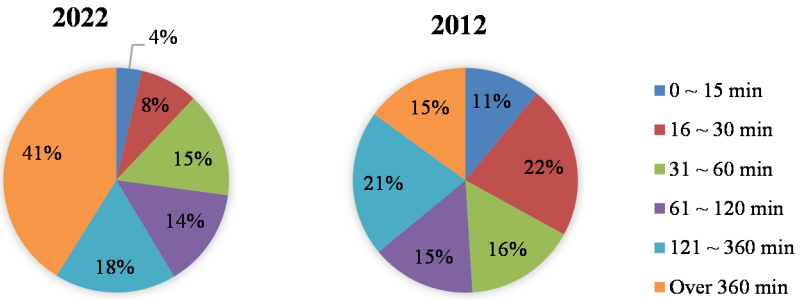
Figure 1.3.136 illustrates that 45% of respondents answered that distance from the facility where they parked vehicles to their destinations were less than 50 m. Compared to 2012, more and more drivers tend to take a longer distance for their destinations.



Source: JST

Figure 1.3.136　Distance from Parking Facilities to Destinations

Figure 1.3.137 shows that the parking duration in 2022 is commonly more than 360 minutes at 41%. The prolonged parking duration trend can be seen compared to the result of the survey in 2012.

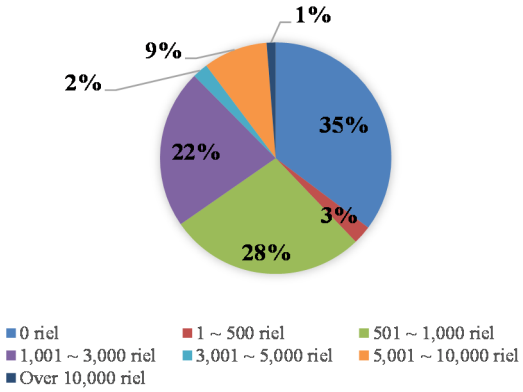


Source: JST

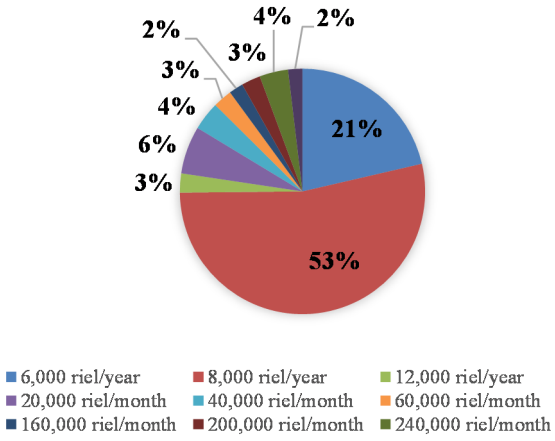
Figure 1.3.137 Parking Duration in 2022 and 2012

In terms of the parking fee that the respondents paid, the dominant answer was 501 to 1,000 KHR, which occupies for 28%, followed by 1,001- 3,000 KHR at 22% in 2022. On the other hand, 35% of respondents answered that they did not pay any parking fee. In case of longer-term payment, the most common fee was 8,000 KHR / year (See Figure 1.3.138).

63% of respondents answered they paid the parking fee "by themselves", while 14% of respondents' parking fee were paid by their employer at some facilities such as Canadia Tower, Vattanac Capital, MEF, etc.



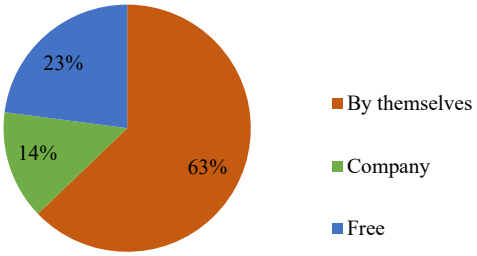
Parking Fee (In case of shorter term payment)



Parking Fee (In case of longer term payment)

Source: JST

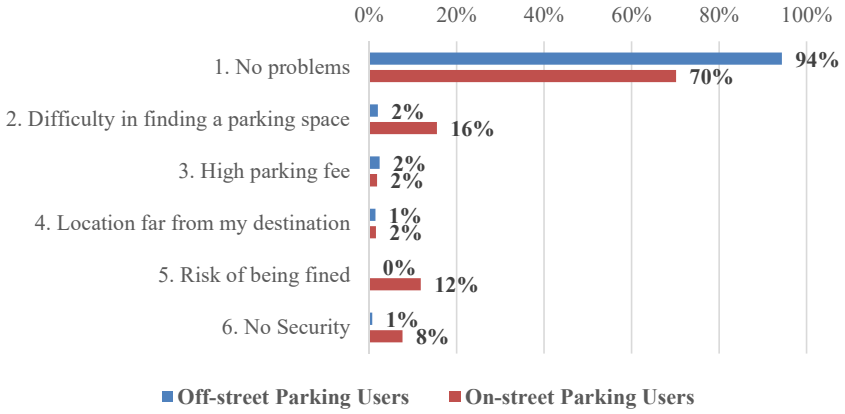
Figure 1.3.138 Distribution of Parking Fee



Source: JST

Figure 1.3.139 Who Pays Parking Fee

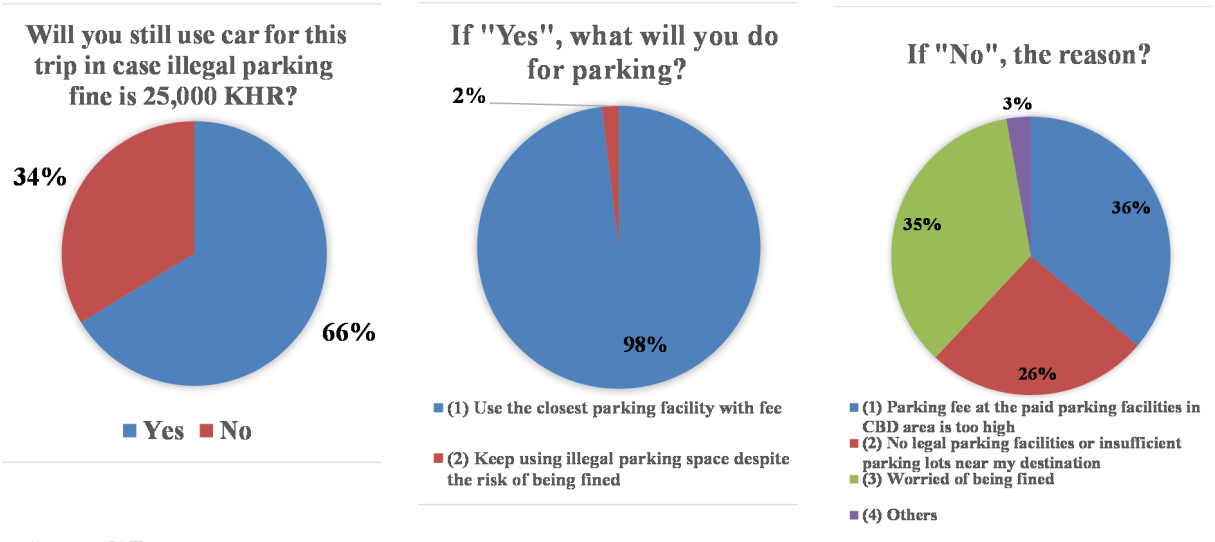
Most respondents of off-street parking users did not perceive any issues with parking facilities while on-street parking facility users raised issues of difficulty in finding a parking space and risk of being fined as shown in Figure 1.3.140.



Note: Multiple answers are allowed.
Source: JST

Figure 1.3.140 Problems Regarding Parking Facility

Figure 1.3.141 shows the opinion of car users on the fine for illegal parking in CBD. 66% of respondents answered that they would continue using a car for traveling to CBD while 34% gave the opposite opinion.



Source: JST

Figure 1.3.141 Willingness of "Not Using Car in CBD" and Opinion of Car Owner on Illegal Parking Fine

1.3.9 RHS Driver Interview Survey

(1) Outline

The RHS Driver Interview Survey aims to get information about actual situation of RHS drivers and to establish the future transport policy in Phnom Penh.

(2) Survey Coverage

Survey Location:

The survey was conducted at the following locations.

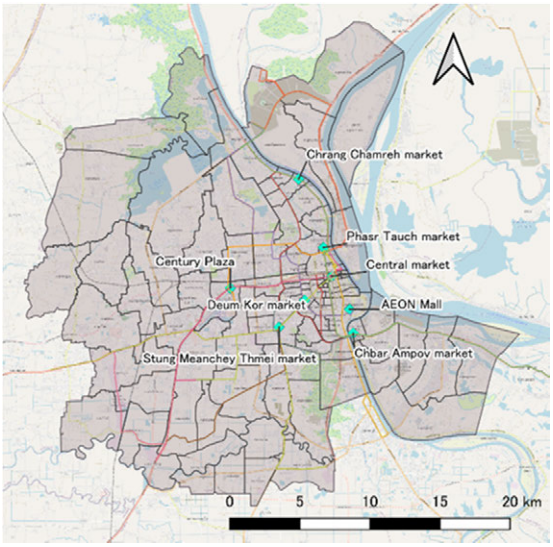
- Chrang Chamreh Market
- Phsar Tauch Market
- Central Market
- AEON Mall 1
- Chbar Ampov Market
- Steung Mean Chey Thmei Market
- Deum Kor Market
- Century Plaza or Pochentong Market

Survey Day:

- The survey was conducted on weekdays (between Tuesday and Thursday).

Sample Size:

- The target sample size is 300 RHS tuk-tuk drivers.



Source: JST

Figure 1.3.142 Map of the RHS Driver Interview Survey Locations

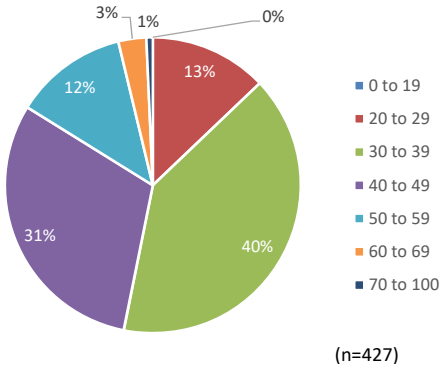
(3) Survey Method

This is a face-to-face interview with the RHS drivers operating around the survey locations to collect drivers' attributes, business performance (number of trips, operation hours, revenue, etc.), effect of COVID-19, RHS applications, and opinions.

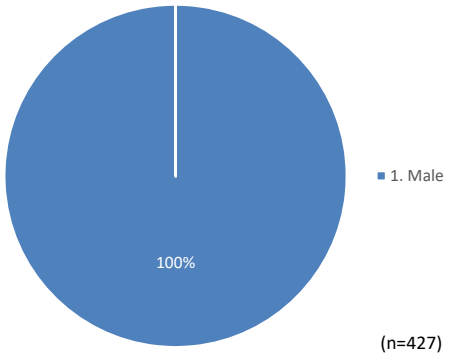
(4) Survey Result of RHS Drivers

1) Personal Characteristics

A total of 427 samples were collected from RHS drivers. The left side of Figure 1.3.143 shows the ratio of RHS driver's age group, indicating 30s and 40s accounts for 71% of all drivers. The right side of Figure 1.3.143 shows the distribution of driver's gender. As shown, all the interviewed drivers were male and no female drivers were observed during the survey.



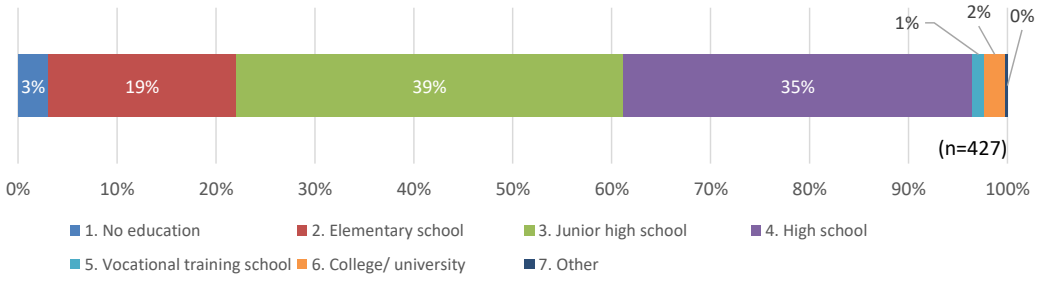
Age of Drivers



Gender of Drivers

Source: JST

Figure 1.3.143 Age and Sex Distribution of RHS Driver

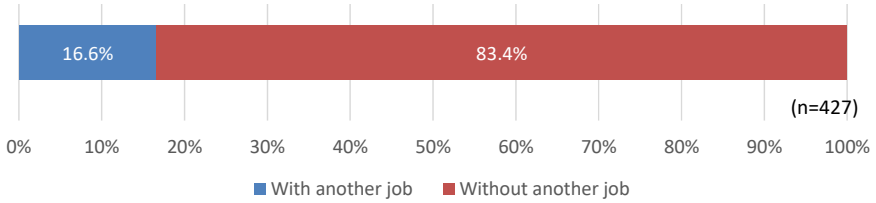


Source: JST

Figure 1.3.144 Educational Background of RHS Drivers

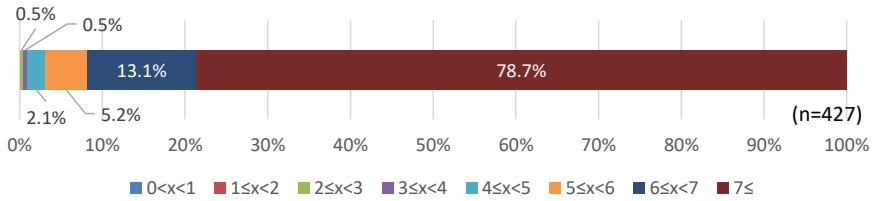
2) Working Condition

As shown in Figure 1.3.145, 83.4% of all respondents do not have another job. 79.2% of all respondents work 7 days a week as shown in Figure 1.3.146. Many of the drivers started using RHS service in 2018 to 2019 as shown in Figure 1.3.147 and Figure 1.3.148.



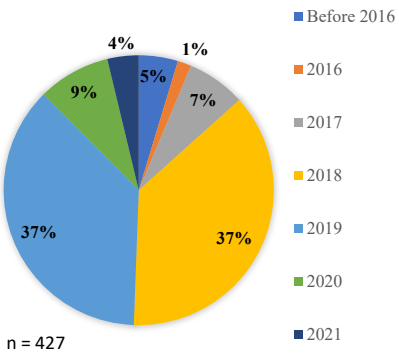
Source: JST

Figure 1.3.145 With / Without Second Job



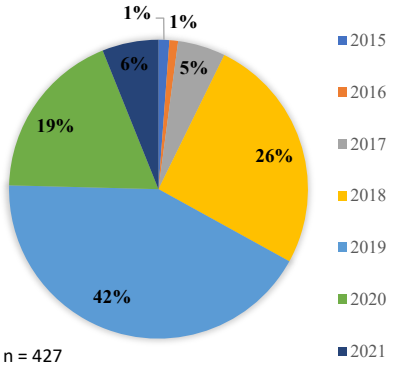
Source: JST

Figure 1.3.146 Working Days per Week



Source: JST

Figure 1.3.147 Year of Starting the Job of Tuk-tuk Driver (RHS Drivers)



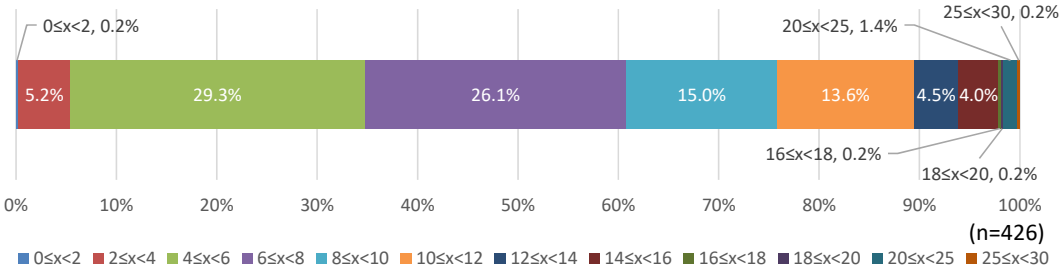
Source: JST

Figure 1.3.148 Year of Starting RHS Application (RHS Drivers)

3) Daily Activity

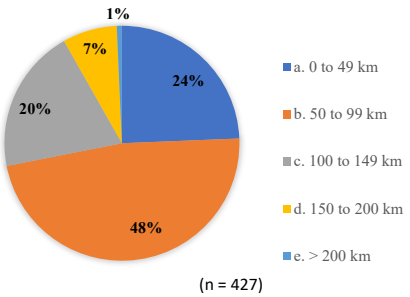
On average, one driver transports eight passengers per day. Mode value is 4-6 passengers per day as shown in Figure 1.3.149. Most of the drivers transport passengers less than 10 times per day.

Daily driving distance with passengers for most drivers is less than 100 km as shown in Figure 1.3.150 and many drivers wait for orders at roadside or parking spaces.

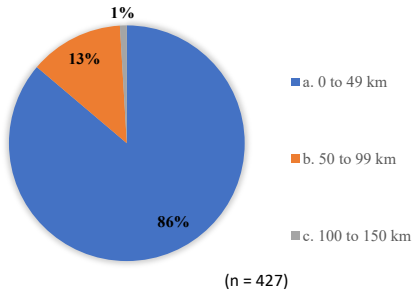


Source: JST

Figure 1.3.149 Average Number of Trips to Send Passengers per Day



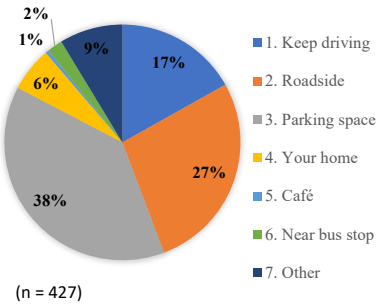
Average daily distance with passengers



Average daily distance without passengers

Source: JST

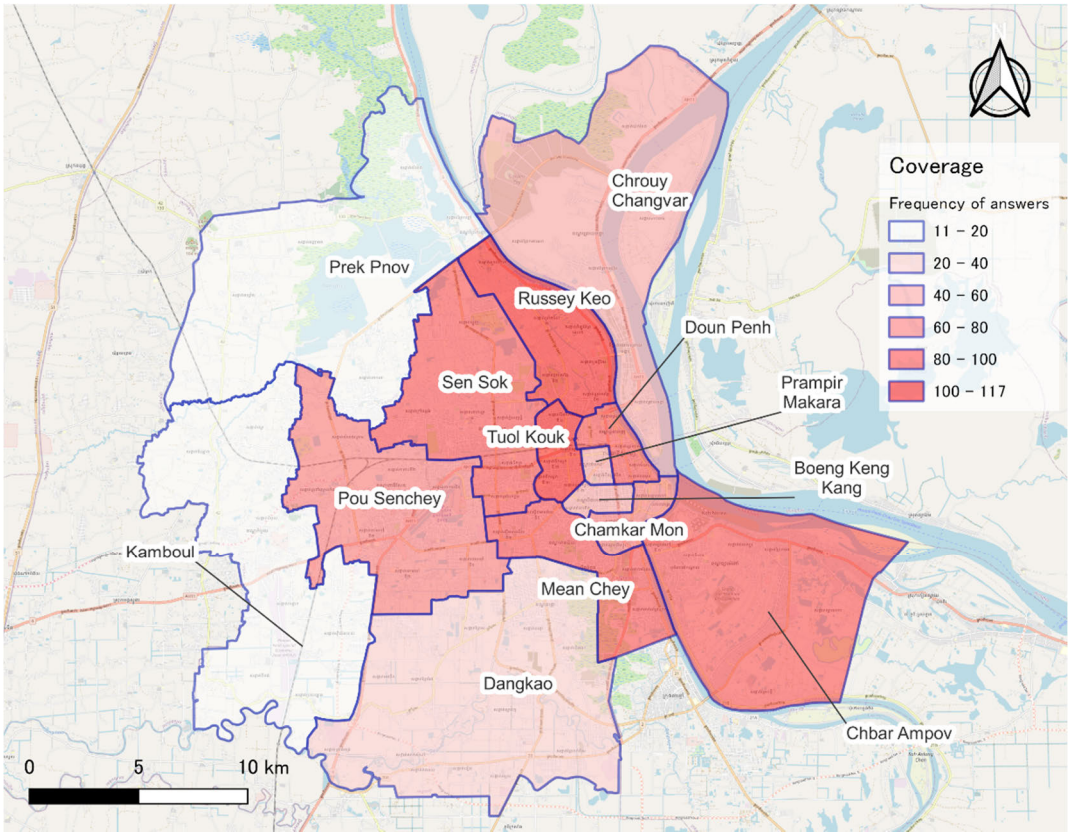
Figure 1.3.150 Average Daily Driving Distance by RHS Drivers



Source: RHS Driver Interview Survey (JST)

Figure 1.3.151 Location when Waiting for Passengers (RHS Drivers)

Figure 1.3.152 illustrates the areas that RHS drivers indicated as their regular coverage of driving service in the RHS Driver Interview Survey. According to the interviews, one RHS driver covers 2.2 districts on average. The city centre is widely covered by many RHS drivers while districts in the suburbs are covered by fewer drivers meaning a less convenient situation of RHS.



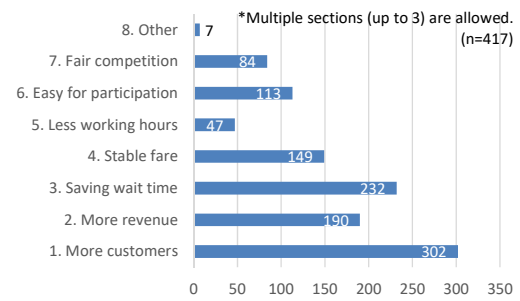
Note: Multiple selections were allowed.
Source: JST

Figure 1.3.152 Coverage of Driving Service by RHS Drivers

Drivers perceive “more customers”, “more revenue”, “saving wait time” as the advantage of using RHS while they perceive “app errors”, “commission fee” and “cannot change fare” as the disadvantages. RHS enables users to take a ride without a bargain with drivers, which is a significant advantage for users. On the other hand, drivers have no discretion on fares, which results in their revenue being affected by

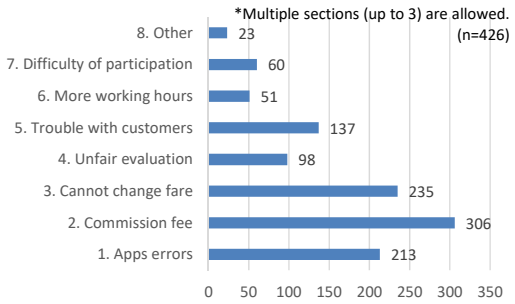
the decisions of an RHS company.

In addition, 73.3% of respondents register at one RHS company only. The registration percentage for PassApp is 84.8% and that of Grab is 31.1% respectively.



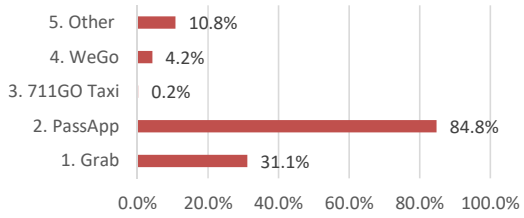
Source: JST

Figure 1.3.153 Advantages of Using RHS Apps



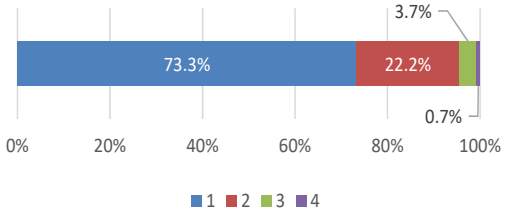
Source: JST

Figure 1.3.154 Disadvantages of Using RHS Apps



Note: Multiple selections are allowed.
Source: JST

Figure 1.3.155 Share of RHS Apps Used by Drivers



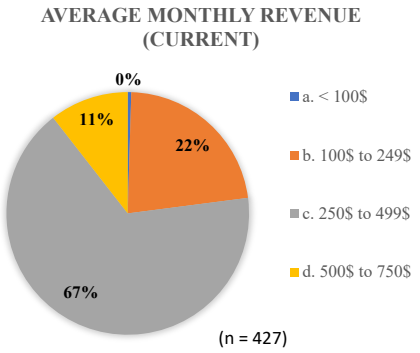
Source: JST

Figure 1.3.156 Number of RHS Apps Used by Drivers

4) Revenue of RHS Drivers and Influence by COVID-19 Pandemic

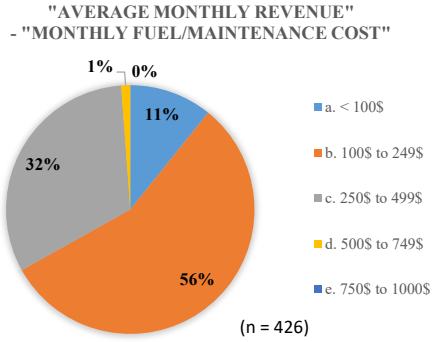
Figure 1.3.157 represents the RHS driver's current revenue received from RHS companies. It should be noted that the current revenue is already affected by the COVID-19 pandemic. The average monthly revenue is USD 315 and the drivers whom revenue varies from USD 250 to USD 499 account for 66.5% of all respondents. Average monthly fuel/ maintenance cost is USD 97 and 60.9% of respondents spend less than USD 100. The RHS driver's actual revenue is estimated by deducting the fuel/maintenance cost from the revenue from RHS companies. The actual revenue is USD 219 on average and the actual revenue of 56.1% of all drivers is in the range of USD 100 to USD 249. Given that the average salary for workers in Phnom Penh is USD 222[4], the revenue of RHS drivers is relatively lower.

[4] Source: https://www.jetro.go.jp/world/search/cost_result?countryId%5b%5d=800



Source: JST

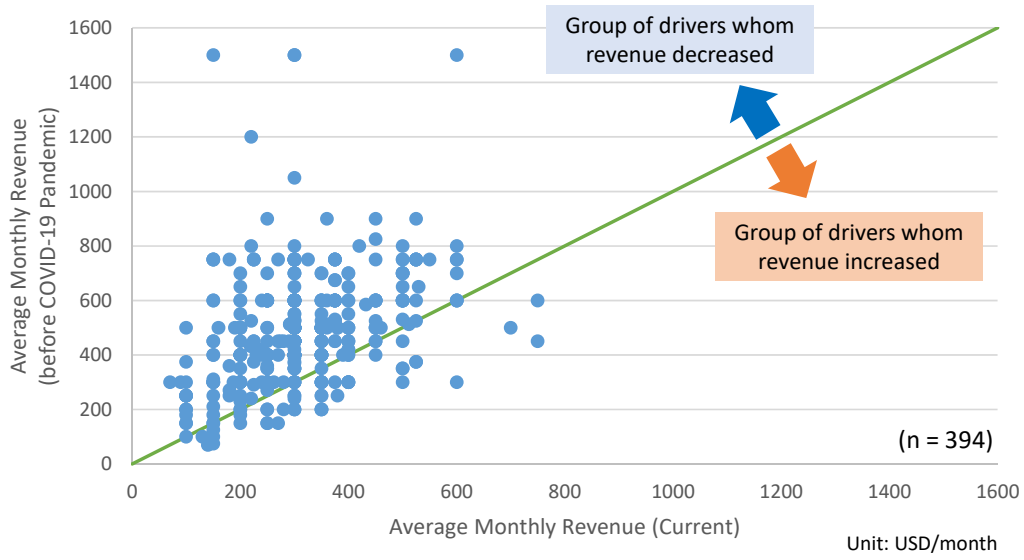
Figure 1.3.157 RHS Driver's Revenue (Current)



Note: It is estimated by deducting monthly fuel/ maintenance cost from monthly income.
Note: USD 1 = KHR 4100
Source: JST

Figure 1.3.158 RHS Driver's Estimated Actual Revenue

Figure 1.3.159 illustrates the distribution of RHS driver's revenue before/after the COVID-19 pandemic. Before the pandemic, 34.7% drivers used to gain USD 500 to USD 749, however, the percentage dropped to 10.5% after the pandemic. 83.2% of all drivers answered that their revenue decreased after the pandemic.



Note: Samples that have no answers for "the revenue before pandemic" are excluded.
Source: JST

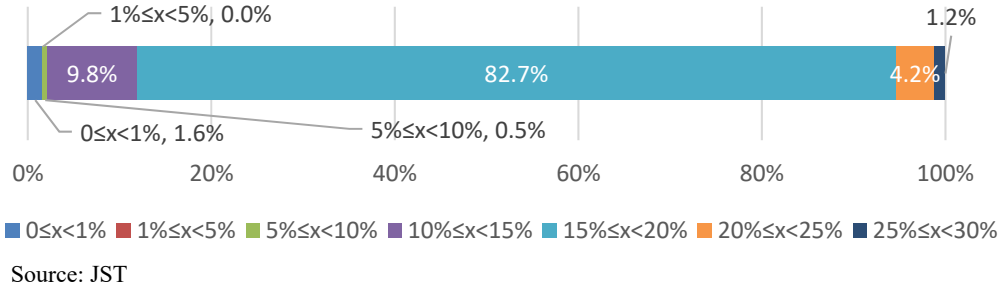
Figure 1.3.159 Comparison of RHS Driver's Revenue before/after COVID-19 pandemic

5) RHS Company and Driver

According to the interview to RHS drivers, the high commission fee by RHS companies (mostly 15% as shown in Figure 1.3.160) is a huge burden on RHS drivers as shown in Figure 1.3.154.

RHS drivers needed to bear some portions of fare discount applied by RHS companies during the pandemic, which is considered to have given a certain impact on drivers. It turned out that there are

drivers that stopped using RHS as a result. Therefore, the sustainability of RHS should be considered if RHS is regarded as public transport.

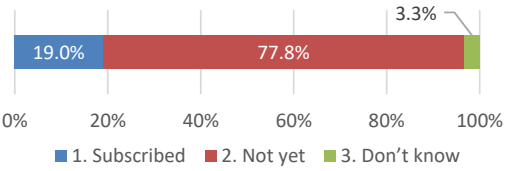


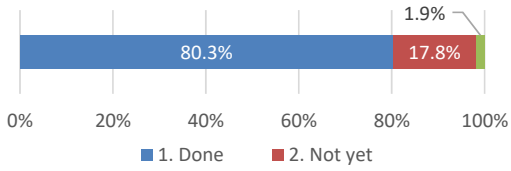
Source: JST

Figure 1.3.160 Commission Fee (Percentage for Fare Revenue)

6) Safety Education and Insurance

Although around 80% drivers have already finished the traffic safety education, only 19.0% of drivers subscribe for insurance for traffic accidents. Improving the insurance subscription rate is required if RHS plays a role in public transport.





Source: JST

Figure 1.3.161 Insurance for Traffic Accidents

Figure 1.3.162 Education for Traffic Safety

1.3.10 Truck Interview Survey (TIS)

(1) Outline

Truck Interview Survey (TIS) includes interviews with companies and drivers, and count surveys at Special Economic Zones (SEZ) and logistics hubs to estimate the percentage of cargo items and intra-regional cargo OD at major cargo hubs.

(2) Survey Coverage

The long list of survey locations for truck interview surveys in 2012 and 2022 are shown in Table 1.3.49.

To capture the changes of truck movement in 2012 and 2022, JST tried to conduct the survey at the same locations chosen in 2012. However, most of them no longer exist or rejected to conduct the survey in 2022. On the other hand, new cargo generation points such as AEON 1 and AEON 2 were observed. Therefore, JST conducted the survey at the same location as the survey 2012 as much as possible and the new cargo generation points.

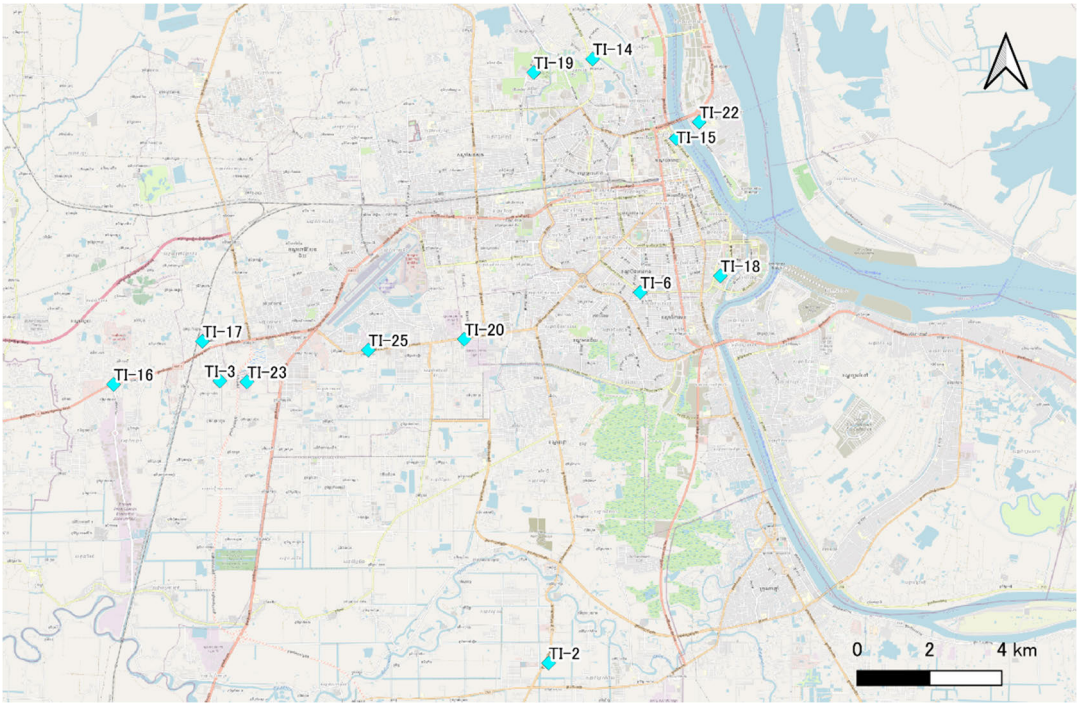
The company interview survey was conducted for 15 companies in total. The truck driver interview survey was conducted at 9 locations out of those 15 companies. JST confirmed that the truck driver interview

survey had been conducted at two locations in 2012 out of the remaining 6 companies. The truck OD table was developed based on the truck driver interview survey at 9 locations in 2022 and 2 locations in 2012 considering the growth ratio of the number of daily truck movement which was covered in the company interview survey.

Table 1.3.49 Survey Locations of Truck Interview Survey

Location ID	Company Name	Truck Driver Interview Survey in 2012	Confirmed Existence /Acceptance of Truck Driver Interview Survey in 2022	Company Interview Survey in 2022	Truck Driver Interview Survey in 2022	Target for Truck OD development
TI-1	Agri-Master Co., Ltd.	Yes	No	No	No	No
TI-2	Cam Paint	Yes	Yes	Yes	Yes	Yes
TI-3	Ming Yang Hung Enterprise (Company Changed from Cambodia Handsome Co., Ltd.)	Yes	No	Yes	No	No
TI-4	Cambodia Brewery Ltd. (Cola Cola)	Yes	No	No	No	No
TI-5	Chip Mong Group (Metal factory)	Yes	No	No	No	No
TI-6	Chip Mong Group (Concrete plant)	Yes	Yes	Yes	Yes	Yes
TI-7	Chip Mong Group (Food and beverage wholesale)	Yes	No	No	No	No
TI-8	High Level logistics (Cambodia) Co., Ltd.	Yes	No	No	No	No
TI-9	Khmer Cement Industry Co., Ltd.	Yes	No	No	No	No
TI-10	LHR Company	Yes	No	No	No	No
TI-11	Vathana Pich	Yes	No	No	No	No
TI-12	Olair Dryport	Yes	No	No	No	No
TI-13	Tech Srun Dryport	Yes	No	No	No	No
TI-14	Vital Premium Water Co, Ltd	Yes	No	Yes	No	Yes
TI-15	Phnom Penh Port	Yes	No	Yes	No	Yes
TI-16	Phnom Penh Special Economic Zone	Yes	Yes	Yes	Yes	Yes
TI-17	Toll Royal Railway Phnom Penh Dry Port/ Toll Cambodia Dry Port	NO	Yes	Yes	Yes	Yes
TI-18-1	AEON 1 (AEON Cambodia)	NO	Yes	Yes	Yes	Yes
TI-18-2	AEON 1 (AEON Mall)	NO	Yes	Yes	Yes	Yes
TI-19-1	AEON 2 (AEON Cambodia)	NO	Yes	Yes	Yes	Yes
TI-19-1	AEON 2 (AEON Mall)	NO	Yes	Yes	Yes	Yes
TI-20	ISI Steel	NO	Yes	Yes	Yes	Yes
TI-22	Vireak Buntham Express	NO	Yes	Yes	No	No
TI-23	Hong Leng Huor (Transport Imp. Exp & Dry Port) co.,Ltd.	NO	Yes	Yes	No	No
TI-25	So Nguon Dry Port	NO	Yes	Yes	No	No

Source: JST



Source: JST

Figure 1.3.163 Survey Locations of Truck Interview Survey

(3) Survey Result

1) Result Comparison between 2012 and 2022

The table below describes the comparison of the survey result between 2012 and 2022. The number of counted trucks at Phnom Penh Port has increased remarkably at the CAGR of 25%.

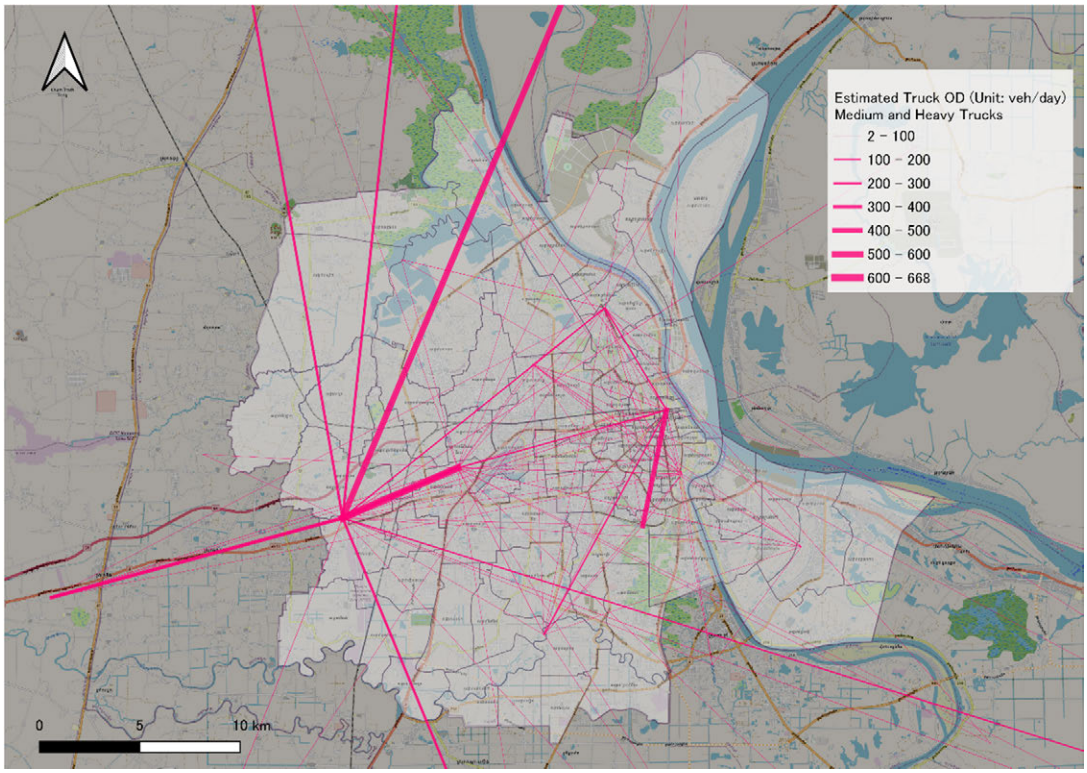
Table 1.3.50 Result Comparison of Truck Interview Survey between 2012 and 2022

ID	Company Name	Counted Trucks in 2012	Counted Trucks in 2022	Interviewed Trucks in 2012	Sample Ratio in 2012	Interviewed Trucks in 2022	Sample Ratio in 2022	CAGR from 2012 to 2022
TI-2	Cam Paint		34	0	0.0%	5	14.7%	
TI-3	Ming Yung Hung Enterprise (Cambodia) Co.,LTD		14	0	0.0%	0	0%	
TI-6	Chip Mong Industries		48	37	0.0%	22	45.8%	
TI-14	N.V.C Corporation Co., Ltd.	24	108	41	170.8%	0	0%	16%
TI-15	Phnom Penh Port	170	1553	66	38.8%	0	0%	25%
TI-16	Phnom Penh Special Economic Zone		4570	0	0.0%	138	3.0%	
TI-17	Toll Royal Railway Phnom Penh Dry Port/ Toll Cambodia Dry Port		304	0	0.0%	48	15.8%	
TI-18-1	AEON 1 (AEON Cambodia)		106	0	0.0%	15	14.2%	
TI-18-2	AEON 1 (AEON Mall)		94	0	0.0%	25	26.6%	

ID	Company Name	Counted Trucks in 2012	Counted Trucks in 2022	Interviewed Trucks in 2012	Sample Ratio in 2012	Interviewed Trucks in 2022	Sample Ratio in 2022	CAGR from 2012 to 2022
TI-19-1	AEON 2 (AEON Cambodia)		30	0	0.0%	8	26.7%	
TI-19-1	AEON 2 (AEON Mall)		41	0	0.0%	8	19.5%	
TI-20	ISI Steel		44	0	0.0%	22	50.0%	
TI-22	Vireak Buntham Express		68	0	0.0%	0	0%	
TI-23	Hong Leng Huor (Transport Imp. Exp & Dry Port) co.,Ltd.		54	0	0.0%	0	0%	
TI-25	So Nguon Dry Port		141	0	0.0%	0	0%	
		194	**7209**	**144**		**291**		

Note: JST

Based on the survey result in 2022, the expansion factor for each survey location was obtained according to the result of the traffic count and the truck driver interview survey. As shown in Figure 1.3.164, the major truck OD can be observed from Kamboul District to Pou Senchey District at around 670 vehicles per day, followed by from Kamboul District to outside Phnom Penh at around 580 vehicles per day.



Note: The data includes “Truck (two axles)” and “Heavy Truck and Trailer”.

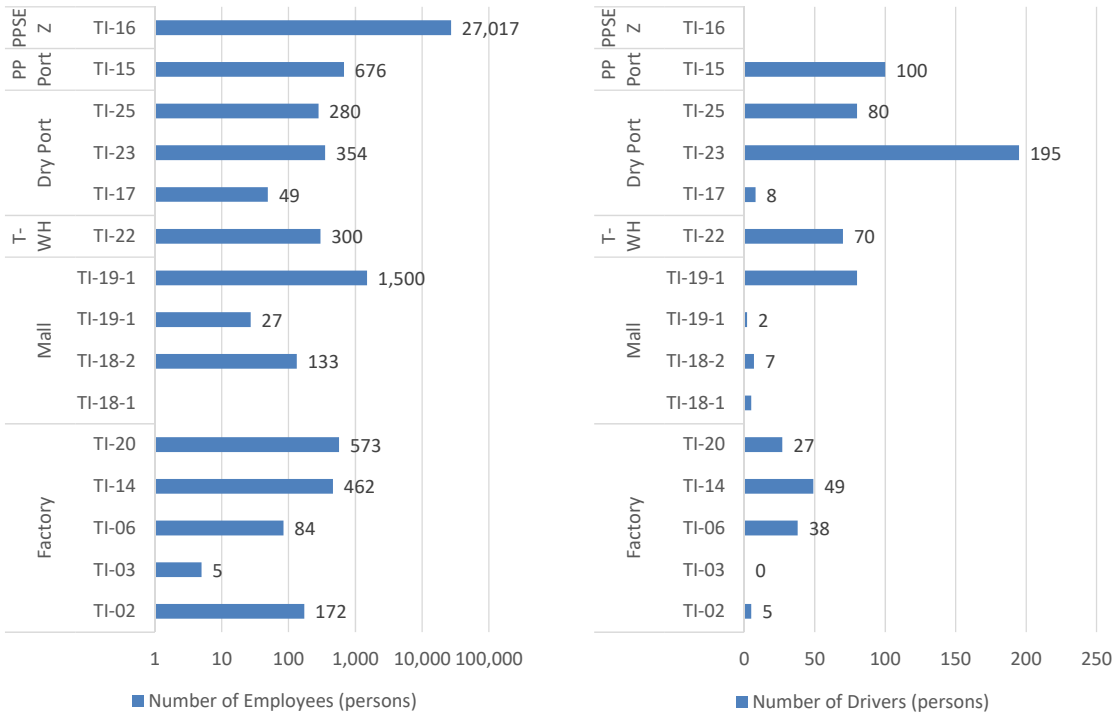
Note: This figure does not describe the distribution of trucks in the entire Phnom Penh nut describes distribution of trucks coming to /departing from the survey locations in the Truck Interview Survey.

Source: JST

Figure 1.3.164 Estimated Truck OD Distribution in 2022

2) Result of Company Interview Survey

The following figures describe the result of the company interview survey. Among all the survey locations, PPSEZ has the largest scale in terms of the number of employees while dry ports and Phnom Penh Port have more of their own drivers than others.

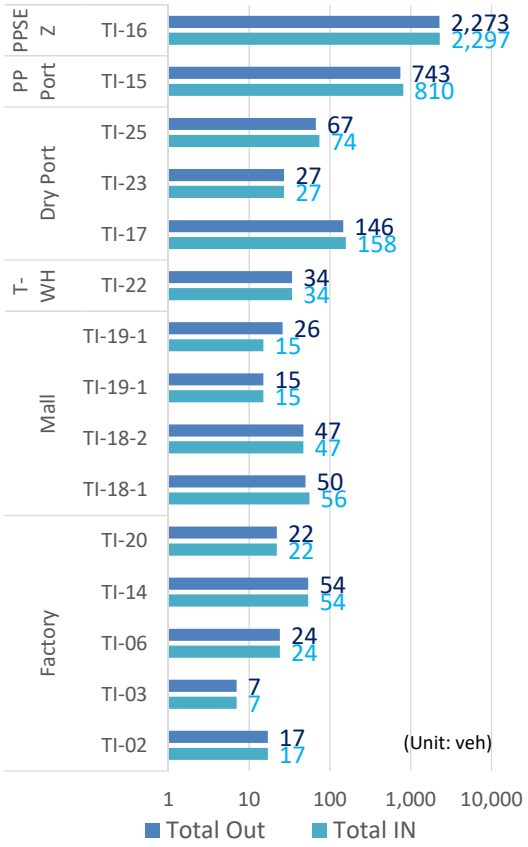


Number of Employees **Number of Drivers**

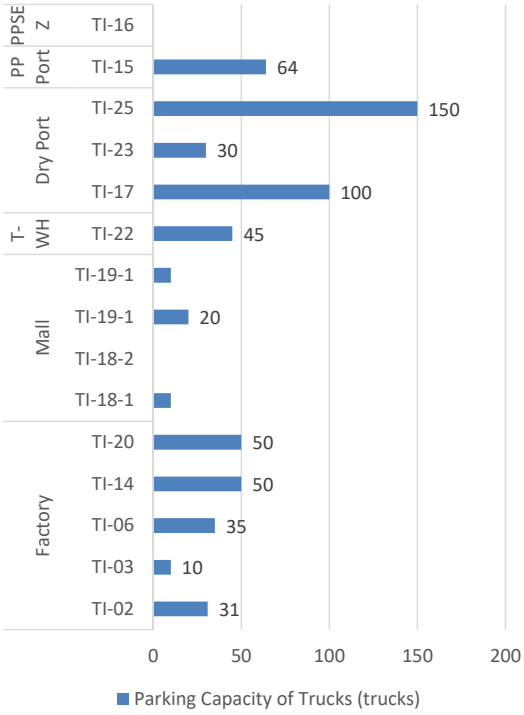
PPSEZ: Phnom Penh Special Economic Zone
PP Port: Phnom Penh Port
T-WH: Transport Warehouse
Note: Number of Employees is described in logarithmic scale.
Source: JST

Figure 1.3.165 Number of Employees and Number of Drivers

At PPSEZ, the total number of in-coming/out-going vehicles is around 2,300 vehicles/day while other locations such as factories, malls and dry ports had around 50 vehicles only.



Total Number of IN/OUT Vehicles



Parking Capacity of Trucks

Note: Number of IN/OUT vehicles is described in logarithmic scale.
Note: There were no answers for the parking Capacity of Trucks at TI-16 and TI-18-2.
Source: JST

Figure 1.3.166 Number of In and Out and Parking Capacity

3) Result of Driver Interview Survey

While the retail stores such as AEON 1 and AEON 2 have a large percentage of "animal products", "fruits and vegetables" and "others", PPSEZ and Toll Railway deal with "fabric" and "rice and grains".

Table 1.3.51 Commodity of Truck

Major Commodity	AEON 1	AEON 2	PPSEZ	Toll Railway
	TI-18	TI-19	TI-16	TI-17
1. Animal Feed	0.0%	0.0%	16.7%	0.0%
2. Animal Products	17.1%	29.4%	2.9%	0.0%
3. Chemicals	2.4%	0.0%	1.4%	0.0%
4. Construction material	0.0%	0.0%	2.2%	0.0%
5. Fabric	4.9%	0.0%	14.5%	31.3%
6. Fertilizer	0.0%	0.0%	0.7%	0.0%
7. Fruits and Vegetable	9.8%	23.5%	0.0%	0.0%
8. Industrial material (Steel, metal)	7.3%	0.0%	7.2%	2.1%
9. Manufactured Goods	2.4%	0.0%	4.3%	8.3%
10. Minerals	0.0%	0.0%	0.0%	0.0%
11. Paper	2.4%	0.0%	5.1%	4.2%

Major Commodity	AEON 1	AEON 2	PPSEZ	Toll Railway
	TI-18	TI-19	TI-16	TI-17
12. Petroleum	0.0%	0.0%	0.0%	0.0%
13. Pharmaceutical	0.0%	0.0%	0.0%	0.0%
14. Plant products	0.0%	0.0%	0.0%	4.2%
15. Plastic and Plastic products	0.0%	5.9%	1.4%	0.0%
16. Rice and Grain products	4.9%	0.0%	11.6%	50.0%
17. Rubber and rubber products	2.4%	0.0%	1.4%	0.0%
18. Seafood	2.4%	5.9%	0.0%	0.0%
19. Sugar and Sugar confectionary	2.4%	0.0%	0.0%	0.0%
20. Other	41.5%	35.3%	30.4%	0.0%
Total	**100%**	**100%**	**100%**	**100%**

Source: JST

Appendix 2 Transport Demand Forecast

2.1 Model Parameter Estimation

2.1.1 Vehicle Ownership Model (VOM)

(1) Model Structure

A household vehicle ownership model is developed as a discrete choice model using household samples of the Person Trip Survey and Commuter Survey. The model divides households into 3 groups: "MC1" households owning one motorcycle, "MC2" households owning two or more motorcycles, and "Car" households owning cars. The three groups share 99% of all sample households.

The utility function of the model is formulated with the Alternative Specific Constant (ASC) and household income as variables as shown in Table 2.1.1. The household income is divided into 7 levels as shown in Table 2.1.2, and the representative values are used as variables. The choice probability of each alternative is calculated by the following formula using the utility function.

$$P_i = \frac{\exp(V_i)}{\sum_i \exp(V_i)}$$

P_i : Probability of choosing vehicle ownership i

V_i : Utility function of vehicle ownership i

Table 2.1.1 Utility Function of Vehicle Ownership Model

Name	Specification
MC1	V_MC1 = ASC_1 * one + B_X1 * HHInc
MC2	V_MC2 = ASC_2 * one
Car	V_Car = ASC_3 * one + B_X3 * HHInc

Source: JST

Table 2.1.2 Household Monthly Income Group

ID	Group	Typical
1	Under 250 USD	124.5 USD
2	250 - 499 USD	374.5 USD
3	500 - 749 USD	624.5 USD
4	750 - 999 USD	874.5 USD
5	1,000 - 1,499 USD	1,249.5 USD
6	1,500 - 1,999 USD	1,749.5 USD
7	Over 2,000 USD	2,500.0 USD

Source: JST

(2) Parameter Estimation Results

The summary and estimated parameter are shown in Table 2.1.3 and Table 2.1.4.

Table 2.1.3 Summary of Vehicle Ownership Model Parameter Estimation

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	4
Number of observations:	4948
Number of individuals:	4948
Null log-likelihood:	-5435.934
Cte log-likelihood:	-5209.529
Init log-likelihood:	-5435.934
Final log-likelihood:	-4863.297
Likelihood ratio test:	1145.272
Rho-square:	0.105
Adjusted rho-square:	0.105

Source: JST

Table 2.1.4 Estimated Parameter of Vehicle Ownership Model

Name	Value	Std err	t-test	p-value
ASC_1	0	fixed		
ASC_2	-0.379	0.0897	-4.23	0
ASC_3	-1.38	0.0965	-14.35	0
B_X1	-0.00155	0.000119	-13.03	0
B_X3	0.000963	6.50E-05	14.82	0

Source: JST

(3) Model Validation

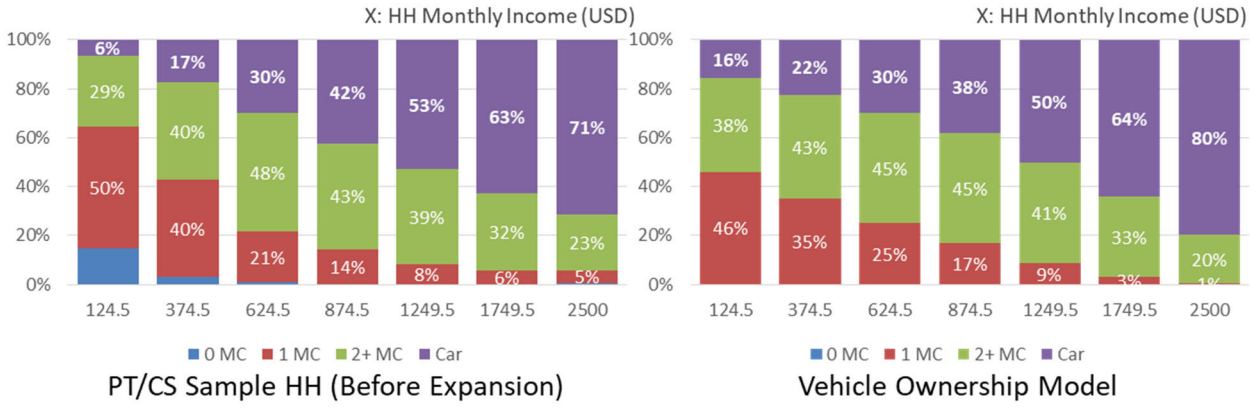
Table 2.1.5 compares the PT/CS survey samples with the estimated number of households for each vehicle ownership group based on the developed model. The difference in the number of households is 2.3% in maximum. Figure 2.1.1 shows the ratio of vehicle ownership groups by income group.

Figure 2.1.2 compares the number of households by income group by vehicle ownership type in the 2012 PT survey and the 2022 PT/CS survey for reference. In general, the number of middle- and high-income households is increasing, and the car ownership rate is increasing in the middle-income group.

Table 2.1.5 Comparison of PT/CS Samples and Model Estimation Results

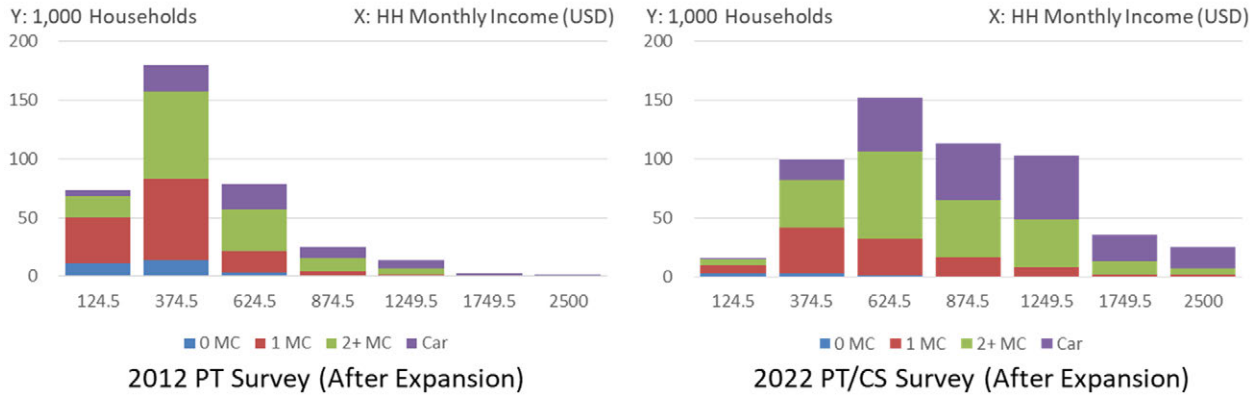
	MC1	MC2	Car
1 PT/CS Sample Households*1	979	2,059	1,910
2 Model Estimate Households	1,002	2,086	1,926
2 / 1	102.3%	101.3%	100.8%

Unit: 1,000 Households, *1: Before Expansion
Source: JST



Source: JST

Figure 2.1.1 Model Validation by Household Monthly Income Level



Source: JST

Figure 2.1.2 No. of Households by Income and Vehicle Ownership Group in 2012 and 2022

2.1.2 Trip Frequency Model (TFM)

(1) Model Structure

A trip frequency model is developed for 5 trip purposes using samples from the PT Survey. As shown in Table 2.1.6, more than 99% of the samples for all purposes fall within the range of 0 to 2 trip frequencies, so a discrete selection model that selects 0, 1, and 2 trip frequencies for each purpose was employed. Samples who made 3 or more trips for the same purpose were grouped into the trip frequency 2 group and used for parameter estimation. The explanatory variables for the trip frequency model were gender, occupation, and household income, as shown in Table 2.1.7. The selection probability of each option is calculated by the following formula using the utility function.

$$P_i = \frac{\exp(V_i)}{\sum_i \exp(V_i)}$$

P_i : Probability of choosing option i

V_i : Utility function of option i

Table 2.1.6 Trip Frequency by Trip Purpose in PT Survey

Frequency	HTW	HTSc	HTSh	HTO	NHB
0	56.61%	70.15%	78.67%	87.95%	95.11%
1	31.38%	21.70%	20.43%	7.75%	3.49%
2	11.85%	7.95%	0.90%	3.63%	1.16%
3	0.17%	0.20%	0.00%	0.23%	0.03%
4	0.00%	0.00%	0.00%	0.43%	0.10%
5	0.00%	0.00%	0.00%	0.00%	0.07%
6	0.00%	0.00%	0.00%	0.00%	0.00%
7	0.00%	0.00%	0.00%	0.00%	0.03%

Source: JST

Table 2.1.7 Explanatory Variables of Trip Frequency Model

Name	Specification
Wrkr	Dummy variable for workers as his/her attribute. 1 if he/she is worker.
Stdt	Dummy variable for students as his/her attribute. 1 if he/she is student.
Othr	Dummy variable for others as his/her attribute. 1 if he/she is not worker nor student.
Female	Dummy variable for female. 1 if he/she is female.
HHIncome	Household monthly income in USD.

Source: JST

(2) Parameter Estimation Results

The structure of utility function and the results of parameter estimation is shown in the following.

1) Home to Work (HTW)

Table 2.1.8 Utility Function of Trip Frequency Model (HTW)

Alternative	Utility Function
0	V_0 = ASC_0 * one + B_Female * Female
1	V_1 = ASC_1 * one + B_X1 * HHIncome + B_Wrkr * Wrkr
2	V_2 = ASC_2 * one + B_Wrkr * Wrkr

Source: JST

Table 2.1.9 Summary of HTW Trip Frequency Model Parameter Estimation

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	5
Number of observations:	3005
Null log-likelihood:	-3301.33
Cte log-likelihood:	-2825.894
Init log-likelihood:	-3301.33
Final log-likelihood:	-1866.508

Name	Value
Likelihood ratio test:	2869.644
Rho-square:	0.435
Adjusted rho-square:	0.433

Source: JST

Table 2.1.10 Estimated Parameter of Trip Frequency Model (HTW)

Name	Value	Std err	t-test	p-value
ASC_0	0	fixed		
ASC_1	-3.78	0.204	-18.51	0
ASC_2	-4.42	0.188	-23.52	0
B_Female	1.21	0.109	11.14	0
B_Wrkr	4.74	0.191	24.82	0
B_X1	0.000312	8.53E-05	3.65	0

Source: JST

2) Home to School (HTSc)

Table 2.1.11 Utility Function of Trip Frequency Model (HTSc)

Alternative	Utility Function
0	V_0 = ASC_0 * one
1	V_1 = ASC_1 * one + B_Stdt * Stdt
2	V_2 = ASC_2 * one + B_Stdt * Stdt

Source: JST

Table 2.1.12 Summary of Trip Frequency Model Parameter Estimation (HTSc)

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	3
Number of observations:	3005
Null log-likelihood:	-3301.33
Cte log-likelihood:	-2357.774
Init log-likelihood:	-3301.33
Final log-likelihood:	-638.419
Likelihood ratio test:	5325.822
Rho-square:	0.807
Adjusted rho-square:	0.806

Source: JST

Table 2.1.13 Estimated Parameter of Trip Frequency Model (HTSc)

Name	Value	Std err	t-test	p-value
ASC_0	0	fixed		
ASC_1	-7.96	1	-7.96	0
ASC_2	-8.94	1	-8.93	0
B_Stdt	11.3	1.02	11.09	0

Source: JST

3) Home to Shopping (HTSh)

Table 2.1.14 Utility Function of Trip Frequency Model (HTSh)

Alternative	Utility Function
0	V_0 = ASC_0 * one + B_Female * Female
1	V_1 = ASC_1 * one + B_Wrkr * Wrkr + B_Othr * Othr
2	V_2 = ASC_2 * one + B_Wrkr * Wrkr + B_Othr * Othr

Source: JST

Table 2.1.15 Summary of Trip Frequency Model Parameter Estimation (HTSh)

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	5
Number of observations:	3005
Null log-likelihood:	-3301.33
Cte log-likelihood:	-1669.461
Init log-likelihood:	-3301.33
Final log-likelihood:	-1165.611
Likelihood ratio test:	4271.438
Rho-square:	0.647
Adjusted rho-square:	0.645

Source: JST

Table 2.1.16 Estimated Parameter of Trip Frequency Model (HTSh)

Name	Value	Std err	t-test	p-value
ASC_0	0	fixed		
ASC_1	-5.81	0.35	-16.6	0
ASC_2	-8.93	0.397	-22.48	0
B_Female	-1.72	0.118	-14.62	0
B_Othr	5.42	0.36	15.05	0
B_Wrkr	3.55	3.42E-01	10.38	0

Source: JST

4) Home to Others (HTO)

Table 2.1.17 Utility Function of Trip Frequency Model (HTO)

Alternative	Utility Function
0	V_0 = ASC_0 * one + B_Female * Female
1	V_1 = ASC_1 * one + B_Wrkr * Wrkr + B_Othr * Othr
2	V_2 = ASC_2 * one + B_Wrkr * Wrkr + B_Othr * Othr

Source: JST

Table 2.1.18 Summary of Trip Frequency Model Parameter Estimation (HTO)

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	5
Number of observations:	3005
Null log-likelihood:	-3301.33
Cte log-likelihood:	-1341.163
Init log-likelihood:	-3301.33
Final log-likelihood:	-1240.545
Likelihood ratio test:	4121.569
Rho-square:	0.624
Adjusted rho-square:	0.623

Source: JST

Table 2.1.19 Estimated Parameter of Trip Frequency Model (HTO)

Name	Value	Std err	t-test	p-value
ASC_0	0	fixed		
ASC_1	-3.47	0.185	-18.8	0
ASC_2	-4.06	0.194	-20.96	0
B_Female	0.557	0.127	4.4	0
B_Othr	2.75	0.217	12.7	0
B_Wrkr	1.29	1.90E-01	6.79	0

Source: JST

5) Non-Home Based (NHB)

Table 2.1.20 Utility Function of Trip Frequency Model (NHB)

Alternative	Utility Function
0	V_0 = ASC_0 * one
1	V_1 = ASC_1 * one + B_X1 * HHIncome + B_Wrkr * Wrkr
2	V_2 = ASC_2 * one + B_X2 * HHIncome + B_Wrkr * Wrkr

Source: JST

Table 2.1.21 Summary of Trip Frequency Model Parameter Estimation (NHB)

Name	Value
Model:	Multinomial Logit
Number of estimated parameters:	5
Number of observations:	3005
Null log-likelihood:	-3301.33
Cte log-likelihood:	-674.877
Init log-likelihood:	-3301.33
Final log-likelihood:	-651.097
Likelihood ratio test:	5300.466
Rho-square:	0.803
Adjusted rho-square:	0.801

Source: JST

Table 2.1.22 Estimated Parameter of Trip Frequency Model (NHB)

Name	Value	Std err	t-test	p-value
ASC_0	0	fixed		
ASC_1	-4.19	0.238	-17.58	0
ASC_2	-5.99	0.375	-15.98	0
B_Wrkr	0.457	0.183	2.5	0.01
B_X1	0.00055	0.000152	3.63	0
B_X2	0.00121	2.10E-04	5.73	0

Source: JST

(3) Model Validation

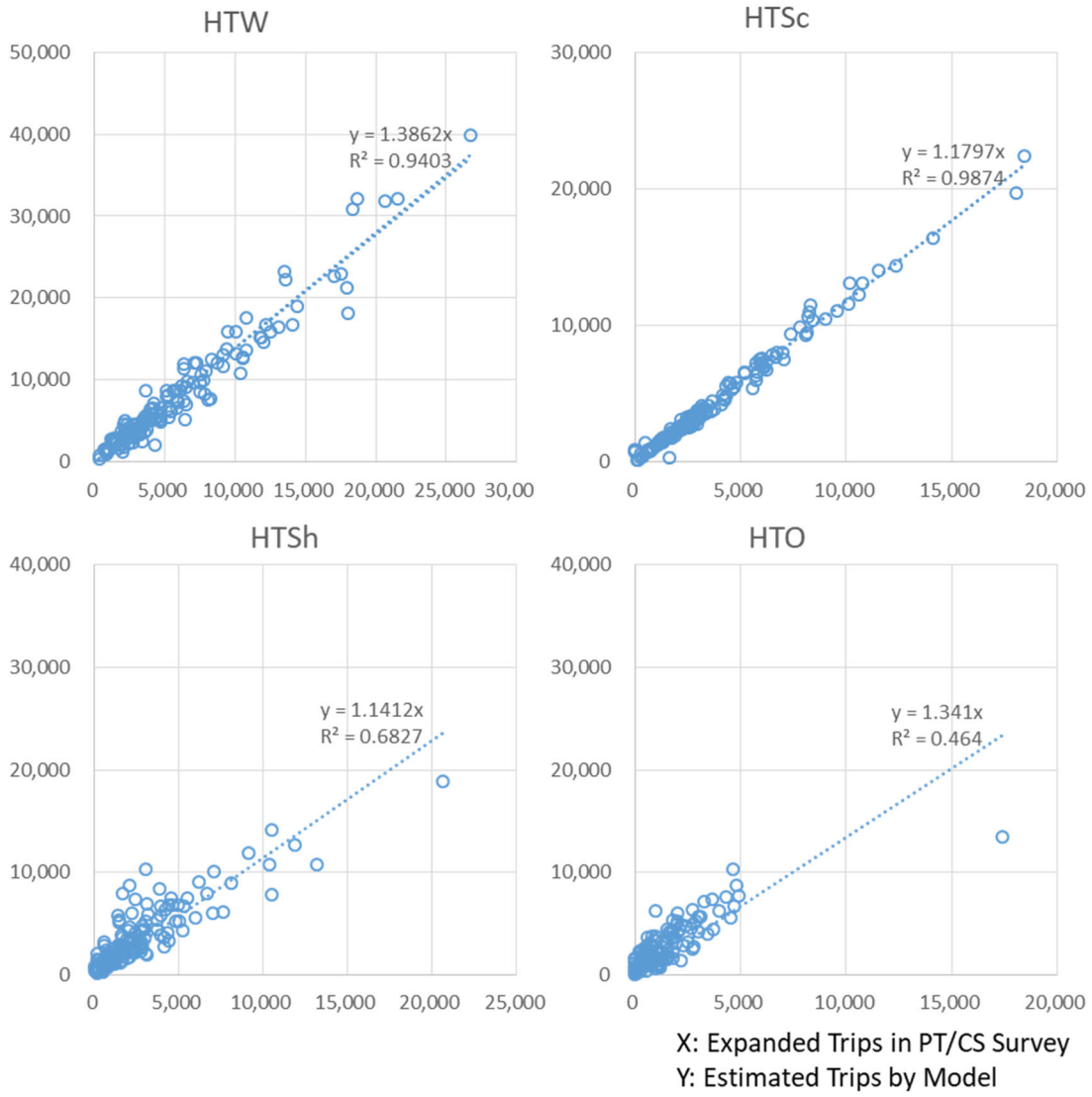
Table 2.1.23 shows the number of trips by purpose and occupation observed in PT survey samples and that estimated by the developed model. It is confirmed the number of trips in each cell is close.

As reference, Figure 2.1.3 compares the number of trips by purpose and by TAZ between the PT/CS survey sample (after expansion) and model estimates. Commuting trips, which account for 70% of all trips after the expansion of the PT survey sample, show good fitness in terms of R squared. Compared to the PT survey conducted by Activity Diary Survey form, the number of trips after the expansion tends to be lower than the model-estimated value because the trip rate in the CS survey is lower.

Table 2.1.23 No. of Trips by Purpose (Observation and Model Estimation)

Observation in PT Survey (Before Expansion)					
	HTW	**HTSc**	**HTSh**	**HTO**	**NHB**
Worker	1,626	2	403	293	135
Student	25	1,140	9	37	43
Others	14	0	256	161	11
Estimation by Model					
	HTW	**HTSc**	**HTSh**	**HTO**	**NHB**
Worker	1,624	1	402	293	130
Student	33	1,141	9	46	43
Others	8	0	256	152	16

Unit: Trips per day
Source: JST



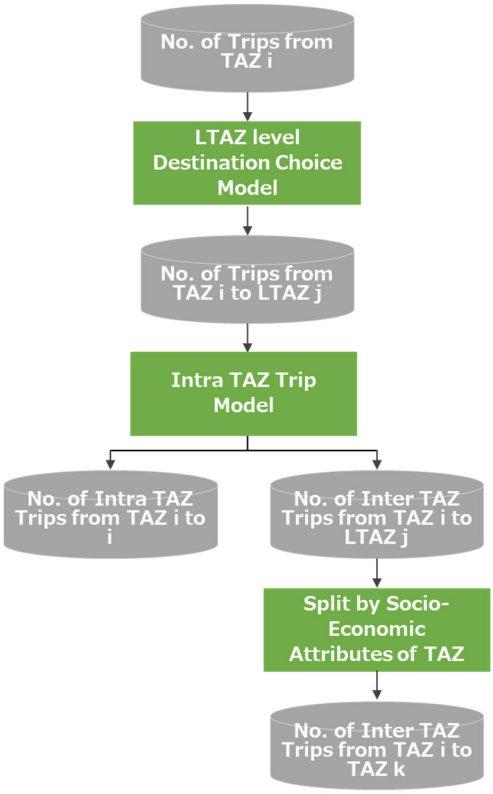
Source: JST

Figure 2.1.3 No. of Trips by TAZ by Purpose (Expanded PT/CS Samples and Model)

2.1.3 Destination Choice Model (DCM)

(1) Model Structure

After several trials, the three-step destination choice model, which consists of LTAZ level destination model, Intra TAZ trip model and split by socio-economic attributes as shown on Figure 2.1.4. Firstly, the LTAZ level destination model, which is a multinomial choice model, selects a destination from 14 items. Secondly, the Intra TAZ trip model, which is a binomial choice model, splits Intra TAZ trips and Inter TAZ trips in case that LTAZ of an origin and a destination are the same. Lastly, the Inter TAZ trips are split by socio-economic attributes of TAZ. The utility functions and the result of parameter estimation are described in the following pages.



Source: JST

Figure 2.1.4 Flow of Destination Choice Model

(2) Parameter Estimation Results (LTAZ Destination Choice)

Table 2.1.24 Explanatory Variables of LTAZ Destination Choice Model

Name	Specification
WrkrAtWorkX	Number of workers at workplace in destination alternative LTAZ X.
StdtAllAtSchoolX	Number of students at school in destination alternative LTAZ X.
LnImpX	Natural log of impedance km between origin LTAZ and destination alternative LTAZ X.

Source: JST

Table 2.1.25 Utility Function of LTAZ Destination Choice Model

Alternative	Utility Function
LTAZ01	V_01 = B_Wrkr * WrkrAtWork01 + B_Stdt * StdtAllAtSchool01 + B_Imp * LnImp01
LTAZ02	V_02 = B_Wrkr * WrkrAtWork02 + B_Stdt * StdtAllAtSchool02 + B_Imp * LnImp02
LTAZ03	V_03 = B_Wrkr * WrkrAtWork03 + B_Stdt * StdtAllAtSchool03 + B_Imp * LnImp03
LTAZ04	V_04 = B_Wrkr * WrkrAtWork04 + B_Stdt * StdtAllAtSchool04 + B_Imp * LnImp04
LTAZ05	V_05 = B_Wrkr * WrkrAtWork05 + B_Stdt * StdtAllAtSchool05 + B_Imp * LnImp05
LTAZ06	V_06 = B_Wrkr * WrkrAtWork06 + B_Stdt * StdtAllAtSchool06 + B_Imp * LnImp06
LTAZ07	V_07 = B_Wrkr * WrkrAtWork07 + B_Stdt * StdtAllAtSchool07 + B_Imp * LnImp07
LTAZ08	V_08 = B_Wrkr * WrkrAtWork08 + B_Stdt * StdtAllAtSchool08 + B_Imp * LnImp08
LTAZ09	V_09 = B_Wrkr * WrkrAtWork09 + B_Stdt * StdtAllAtSchool09 + B_Imp * LnImp09
LTAZ10	V_10 = B_Wrkr * WrkrAtWork10 + B_Stdt * StdtAllAtSchool10 + B_Imp * LnImp10
LTAZ11	V_11 = B_Wrkr * WrkrAtWork11 + B_Stdt * StdtAllAtSchool11 + B_Imp * LnImp11
LTAZ12	V_12 = B_Wrkr * WrkrAtWork12 + B_Stdt * StdtAllAtSchool12 + B_Imp * LnImp12
LTAZ13	V_13 = B_Wrkr * WrkrAtWork13 + B_Stdt * StdtAllAtSchool13 + B_Imp * LnImp13
LTAZ14	V_14 = B_Wrkr * WrkrAtWork14 + B_Stdt * StdtAllAtSchool14 + B_Imp * LnImp14

Source: JST

Table 2.1.26 Summary of LTAZ Destination Choice Model Parameter Estimation

HHVO=3 Car	HTW	HTSc	HTSh	HTO	NHB
Number of estimated parameters:	2	2	2	2	2
Number of observations:	673	526	260	260	106
Number of individuals:	673	526	260	260	106
Null log-likelihood:	-1776.086	-1388.144	-686.155	-686.155	-279.74
Cte log-likelihood:	-1727.153	-1303.155	-662.132	-649.665	-253.72
Init log-likelihood:	-1776.086	-1388.144	-686.155	-686.155	-279.74
Final log-likelihood:	-1350.209	-786.851	-221.784	-272.035	-169.999
Likelihood ratio test:	851.754	1202.586	928.743	828.24	219.481
Rho-square:	0.24	0.433	0.677	0.604	0.392
Adjusted rho-square:	0.239	0.432	0.674	0.601	0.385

HHVO=2 2MC	HTW	HTSc	HTSh	HTO	NHB
Number of estimated parameters:	2	2	2	2	2
Number of observations:	706	457	275	185	99
Number of individuals:	706	457	275	185	99
Null log-likelihood:	-1863.174	-1206.049	-725.741	-488.226	-261.267
Cte log-likelihood:	-1811.763	-1142.18	-695.043	-451.264	-248.257
Init log-likelihood:	-1863.174	-1206.049	-725.741	-488.226	-261.267
Final log-likelihood:	-1147.729	-595.82	-216.942	-184.872	-178.835
Likelihood ratio test:	1430.891	1220.459	1017.598	606.707	164.863
Rho-square:	0.384	0.506	0.701	0.621	0.316
Adjusted rho-square:	0.383	0.504	0.698	0.617	0.308

HHVO=1 1MC	HTW	HTSc	HTSh	HTO	NHB
Number of estimated parameters:	2	2	2	2	2
Number of observations:	266	153	128	79	99
Number of individuals:	266	153	128	79	99
Null log-likelihood:	-701.989	-403.776	-337.799	-208.486	-261.267
Cte log-likelihood:	-664.547	-371.566	-307.446	-181.815	-248.257
Init log-likelihood:	-701.989	-403.776	-337.799	-208.486	-261.267
Final log-likelihood:	-435.993	-172.55	-134.047	-138.098	-178.835
Likelihood ratio test:	531.992	462.452	407.505	140.775	164.863
Rho-square:	0.379	0.573	0.603	0.338	0.316
Adjusted rho-square:	0.376	0.568	0.597	0.328	0.308

Source: JST

Table 2.1.27 Estimated Parameters of LTAZ Destination Choice Model

Model	Name	Value	Std err	t-test	p-value
HHVO=3 HTW	B_Imp	-1.7	0.0613	-27.81	0
	B_Wrkr	2.89E-06	1.43E-06	2.03	0.04
	B_Stdt	0.0	fixed		
HHVO=2 HTW	B_Imp	-2.24	0.0667	-33.51	0
	B_Wrkr	3.35E-06	1.53E-06	2.19	0.03
	B_Stdt	0.0	fixed		
HHVO=1 HTW	B_Imp	-2.23	0.112	-19.96	0
	B_Wrkr	6.59E-06	2.59E-06	2.54	0.01
	B_Stdt	0.0	fixed		
HHVO=3 HTSc	B_Imp	-2.37	0.0812	-29.19	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.98E-05	2.91E-06	6.82	0
HHVO=2 HTSc	B_Imp	-2.73	0.0982	-27.78	0
	B_Wrkr	0.0	fixed		
	B_Stdt	2.48E-05	3.41E-06	7.28	0
HHVO=1 HTSc	B_Imp	-1.74	0.133	-13.13	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.54E-05	4.92E-06	3.14	0
HHVO=3 HTSh	B_Imp	-3.39	0.159	-21.33	0
	B_Wrkr	7.54E-06	3.22E-06	2.34	0.02
	B_Stdt	0.0	fixed		
HHVO=2 HTSh	B_Imp	-3.69	0.181	-20.37	0
	B_Wrkr	0.0	fixed		
	B_Stdt	2.74E-05	6.22E-06	4.41	0
HHVO=1 HTSh	B_Imp	-1.74	0.145	-11.96	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.18E-05	5.4E-06	2.19	0.03
HHVO=3 HTO	B_Imp	-3.06	0.143	-21.42	0
	B_Wrkr	4.16E-06	2.82E-06	1.47	0.14
	B_Stdt	0.0	fixed		
HHVO=2 HTO	B_Imp	-3.28	0.18	-18.25	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.69E-05	6.76E-06	2.51	0.01

Model	Name	Value	Std err	t-test	p-value
HHVO=1 HTO	B_Imp	-0.764	0.175	-4.38	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.74E-05	6.29E-06	2.77	0.01
HHVO=3 NHB	B_Imp	-2.03	0.164	-12.43	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.95E-05	5.74E-06	3.4	0
HHVO=2 NHB	B_Imp	-1.84	0.161	-11.37	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.58E-05	0.000006	2.62	0.01
HHVO=1 NHB	B_Imp	-1.84	0.161	-11.37	0
	B_Wrkr	0.0	fixed		
	B_Stdt	1.58E-05	0.000006	2.62	0.01

Source: JST

(3) Parameter Estimation Results (Intra TAZ Destination Choice)

Table 2.1.28 Explanatory Variables of Intra TAZ Destination Choice Model

Name	Specification
MC1	Dummy variable for household vehicle ownership group = 1, only 1 MC. 1 if his/her household own only 1 MC.
HTSc	Dummy variable for Home to School (HTSc) trip. 1 if the trip purpose is HTSc.
HTSh	Dummy variable for Home to Shopping (HTSh) trip. 1 if the trip purpose is HTSh.
HTW	Dummy variable for Home to Work (HTW) trip. 1 if the trip purpose is HTW.
OTAZAreaLnSqm	Natural log of area (sqm) of the origin TAZ.

Source: JST

Table 2.1.29 Utility Function of Intra TAZ Destination Choice Model

Alternative	Utility Function
InterTAZ	V_0 = ASC_0 * one + B_HTSc * HTSc
IntraTAZ	V_1 = ASC_1 * one + B_OTAZAreaLnSqm * OTAZAreaLnSqm + B_1MC * MC1 + B_HTSh * HTSh + B_HTW * HTW

Source: JST

Table 2.1.30 Summary of Intra TAZ Destination Choice Model Parameter Estimation

Name	Value
Number of estimated parameters:	6
Number of observations:	2754
Number of individuals:	2754
Null log-likelihood:	-1908.927
Cte log-likelihood:	-1806.616
Init log-likelihood:	-1908.927
Final log-likelihood:	-1734.899

Name	Value
Likelihood ratio test:	348.057
Rho-square:	0.091
Adjusted rho-square:	0.088

Source: JST

Table 2.1.31 Estimated Parameter of Intra TAZ Destination Choice Model

Name	Value	Std err	t-test	p-value
ASC_0	2.8	0.429	6.53	0
ASC_1	0	fixed		
B_1MC	0.305	0.109	2.8	0.01
B_HTSc	0.292	0.116	2.51	0.01
B_HTSh	0.474	0.129	3.68	0
B_HTW	0.534	0.116	4.58	0
B_OTAZAreaLnSqm	0.214	0.0286	7.49	0

Source: JST

(4) Split by Socio-economic Attributes of TAZ

Trips of which destination LTAZ is not same as the origin LTAZ and of which destination LTAZ is same as origin LTAZ but split into Inter TAZ trip were split by socio-economic attributes of TAZ. The socio-economic attributes are used as an explanatory variable of LTAZ destination choice model.

2.1.4 Modal Choice Model (MCM)

(1) Model Structure

After several trials, the Modal choice model was developed with the SP Survey data collected in the Passenger Interview Survey. Considering the scenario of the urban railway construction in the future, a 5-item choice model was employed. Model parameters were estimated for households with car ownership (HHVO=3) and for households without car ownership (HHVO=1, 2) separately. The explanatory variables of the model are total travel time and total travel cost of each mode as well as constants for each choice.

Table 2.1.32 Utility Functions of Modal Choice Model

Alternative	Utility Function
A1_CAR	V1 = ASC_CAR * one + B_TIME * Car_Time_min + B_COST * Car_Cost_Riel
A2_MCY	V2 = ASC_MCY * one + B_TIME * MC_Time_min + B_COST * MC_Cost_Riel
A3_TTK	V3 = ASC_TTK * one + B_TIME * Tuk_Time_min + B_COST * Tuk_Cost_Riel
A4_BUS	V4 = ASC_BUS * one + B_TIME * Bus_Time_min + B_COST * Bus_Cost_Riel
A5_UR	V5 = ASC_UR * one + B_TIME * URail_Time_min + B_COST * URail_Cost_Riel

Note: CAR is not included as a choice for HHVO =1,2
Source: JST

Table 2.1.33 Explanatory Variables for Modal Choice Model

Name	Specification
X_Time_min	Total travel time in minutes when travelling by travel mode X
X_Cost_Riel	Total travel cost in Riel when travelling by travel mode X

Source: JST

(2) Parameter Estimation Results

Table 2.1.34 Result of Parameter Estimation for Modal Choice Model

Name	HHVO=3	HHVO=1,2
Number of estimated parameters:	6	4
Number of observations:	12783	13291
Number of individuals:	12783	13291
Null log-likelihood:	-20573.445	-18425.238
Cte log-likelihood:	-18740.633	-15893.658
Init log-likelihood:	-20573.445	-18425.238
Final log-likelihood:	-16234.551	-13212.281
Likelihood ratio test:	8677.788	10425.915
Rho-square:	0.211	0.283
Adjusted rho-square:	0.211	0.283

Source: JST

Table 2.1.35 Estimated Parameters for Modal Choice Model

HHVO=3

Name	Value	Std err	t-test	p-value
ASC_BUS	-0.0609	0.0313	-1.95	0.05
ASC_CAR	0	fixed		
ASC_MCY	-0.534	0.0279	-19.17	0
ASC_TTK	-0.476	0.0573	-8.31	0
ASC_UR	0.402	0.0316	12.72	0
B_COST	-0.000293	7.02E-06	-41.81	0
B_TIME	-0.142	0.0032	-44.17	0

HHVO=1, 2

Name	Value	Std err	t-test	p-value
ASC_BUS	0	fixed		
ASC_MCY	-0.455	0.0286	-15.91	0
ASC_TTK	0	fixed		
ASC_UR	0.354	0.0312	11.35	0
B_COST	-0.000321	5.36E-06	-59.9	0
B_TIME	-0.118	0.0032	-36.94	0

Source: JST

2.2 Mobility Analysis with Mobile GPS Data

2.2.1 Methodology

This section summarises the application of Mobile Location Records (MLR) data to generate OD matrices and mobility insights in Phnom Penh over several yearly periods. The technical process of how OD matrices were generated from MLRs data is described in 11 steps below, split across 4 sprints.

(1) Sprint 1a. Data Ingestion:

1) Raw Data Collation:

The first stage of analysis required the 2 supplied tables (People and Mobility) to be loaded into the data processing infrastructure (postgres / python / qgis). This was subsequently followed by an additional version 2 ingestion of the Mobility data, resulting in a final, merged dataset housed as the base mobility table:

- **Version 1** (01-31 Jan 2020, 01-31 Jan 2021):
  - Mobility: 148,596,267 rows | 212,067 distinct MAIDs
  - People: 475,333 rows | 475,273 distinct MAIDs
- **Version 2** (01-31 Jan 2020, 01-31 Jan 2021, 01-31 Mar 2022):
  - base mobility: 152,248,405 rows | 349,492 distinct MAIDs

Neither of the data ingestion reflect continuous data, but instead the following discrete periods:

- JAN 2020: 96,041,202 rows (84,320 distinct MAIDs)
- DEC 2020: 2,461,833 rows (23,076 distinct MAIDs)
- JAN 2021: 50,093232 rows (134,927 distinct MAIDs)
- MAR 2022: 3,651,705 rows (144,465 distinct MAIDs)
- APR 2022: 433 rows (128 distinct MAIDs)

We note that while the data generally covers three discrete months (Jan 2020, Jan 2021, March 2022) there is some spill over into Dec 2020 and Apr 2022. This data was left in the mobility table to ensure as much support was made available as possible for subsequent analyses.

2) Superfluous field removal:

Data loading was followed by a distillation of the supplied schema, removing extraneous fields (e.g. wifi ssid details / postcode / user_agent / ip addresses / altitude / id_type) guided by the project use of geohash6 as the baseline geospatial resolution. The geohash6 areas selected as the basis for geospatial analysis are ~1.2km x 609.4m in area, with Phnom Penh containing ~1900 of these geohash6 cells.

3) Formatting:

A further formatting exercise was then undertaken with missing data and empty strings within the data being converted to nulls, text fields converted to numerical values where appropriate, and currency sign removal. With data in this format, the analysis proceeded to processing.

(2) Sprint 1b. Data Cleansing / Coherency Checks

1) Noise detection/Removal:

The first stage of data cleansing proper was then undertaken, involving removal of spurious and outlying data identified via analysis of metadata within the mobility table. Following consultation and exploration of data distributions, data points were labelled as invalid for analysis where sensor readings corresponded to:

- i. Spurious speeds (negative or null) 17,957,575 records
- ii. Insufficient locational accuracy (> 2km) 17,266,401 records
- iii. Spurious inter-point speeds (> 35m/s) 2,149,044 records
- iv. longitude / latitudes outside of Cambodia 105,471 records
- v. Excessive declared speeds (> 35m/s) 12,198 records
- vi. Spurious GPS accuracies (negative) 290 records

After filtering 41,526,491 mobility data points remained available for the analysis.

2) Coherency Check:

Checks were then performed to assess weather MAIDs seen in the Mobility table matched those in the People table (with this analysis necessarily constrained to version 1 of the dataset, as no update to the people table was available for version 2), while in the first version this was undertaken to generate a coherent mobility dataset (featuring only individuals for which we held metadata), in the second version this coherency check was instead integrated as part of the validation of home/work location detected in the second version of the analysis.

3) Coverage Check:

Analysis of raw data was then performed to confirm sufficient coverage across the target extent (Phnom Penh) to support OD matrix generation. An estimated bounding box for the city extent was applied.

4) Feature Engineering:

Further mobility features were added to reflect key indicators on the validity of each observation. Features added included summarisations in the number of observations seen for each "MAID", observations per day; locational 'entropy' of each individual; whether a mobility observation reflected a movement across geohash6, 7, 8 boundaries; and the time since the previous observation. These additional features become utilised in future filtering and outlier detection stages.

(3) Sprint 1c. Data Summarisation

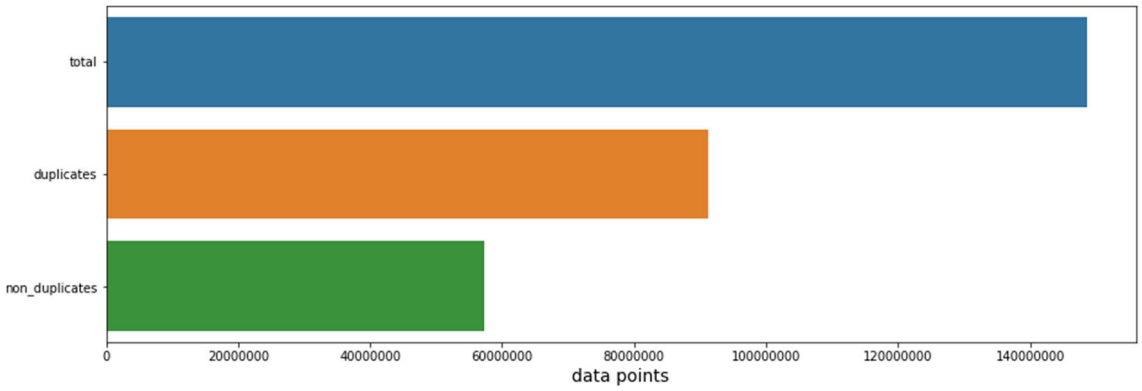
The final stage of the inception sprint reflected a first data summarisation process and illustrating statistics for:

- a. Sensor Accuracies
- b. Distribution of Observations by day of week
- c. Distribution of Observations by time of day
- d. Distribution of individual attributes (home, work, device, price, age, gender)
- e. Distribution of observation attributes (home, work, sensor type, device, price, age, gender)

(4) Sprint 2a. Outlier Removal

1) GPS Duplicate Removal

It was noted that there is a large amount of "Pseudo-duplicates" occurring in the data provided in the mobility table. These are contiguous readings from sensors that are labelled with the same timestamp (second) and the same location (lat/long) as each other. These duplicates are likely the result of sensors emitting several data points at once, but we are unable to identify a route cause within the supplied data. These duplicate points serve only to add noise to the analysis, so they were removed from the data. The extent of this issue is illustrated in Figure 2.2.1.

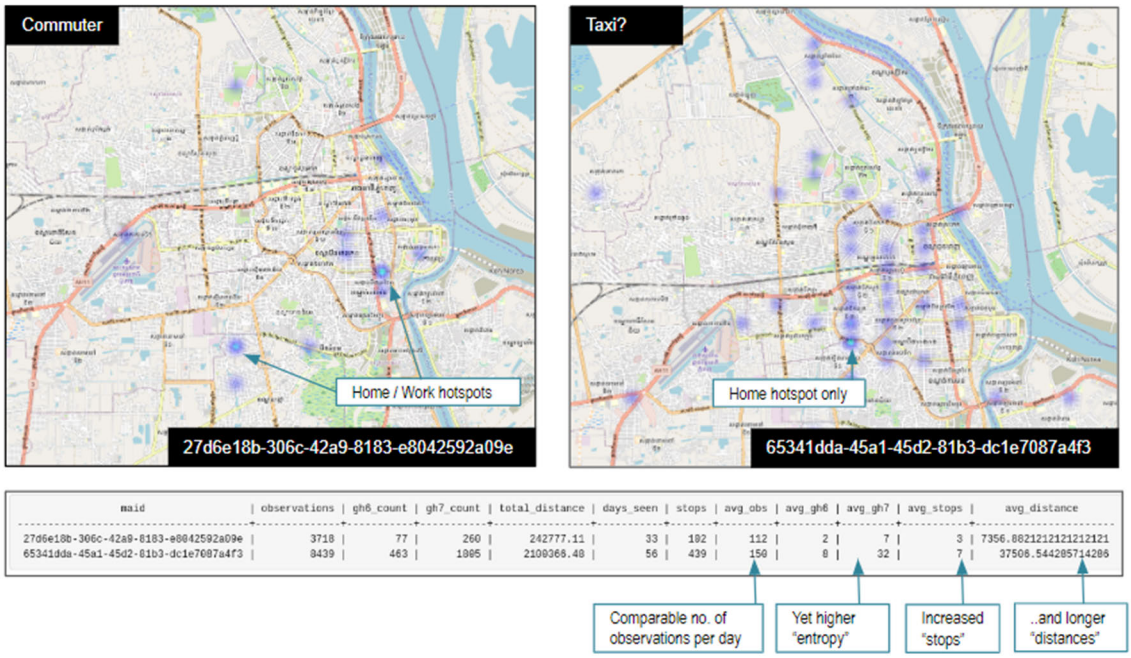


Source: JST

Figure 2.2.1 Analysis of "Pseudo-duplicates" Removal

2) Outlier Detection

Early in version 1 analysis it was noted that 50% of the original MLR data was generated by just 3075 of the 130k MAIDs within pre 2022 records. This equated to just 2.3% of all individuals, with data patterns hence being heavily biased towards them. If left unattended OD outputs based on this data would not reflect normal behaviours. As illustrated in Figure 2.2.2, exploratory analysis identified that many of aberrant MAIDs were likely taxi/public transport drivers, with a high number of observations and corresponding movement patterns reflecting "fares" occurring relatively constantly throughout the day. These will not accurately reflect commuting (home/work) patterns.

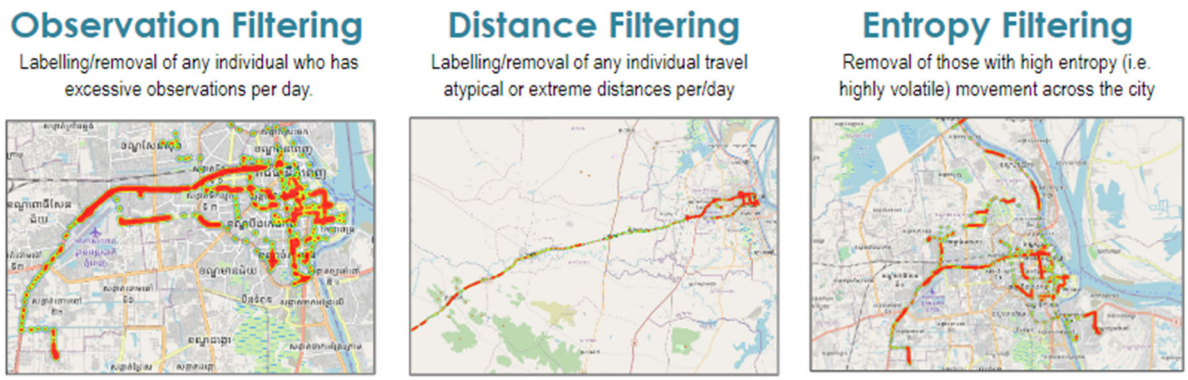


Source: JST

Figure 2.2.2 Examples of Different Movement Patterns between Normal Commuter and Taxi Driver in Data

Such trips tend to reflect the movement of passengers who themselves do not own vehicles, resulting in outputs the would be highly skewed by transport hubs (e.g., airports.) To prevent highly skewed and inaccurate Origin Destination models, several filtering stages were proposed to remove these outliers:

- i. **Observation Filtering**: Filtering of any individual who has excessive observations per day.
- ii. **Distance Filtering**: Filtering of any individual travelling atypical or extreme distances per/day
- iii. **Entropy Filtering**: Filtering of those with high entropy (i.e., highly volatile) movement across the city



Source: JST

Figure 2.2.3 Examples of Methods Utilised to Explore Identification of Outlying MAIDs

3) Outlier Labelling

In order to label these outlying MAIDs (so they can potentially be removed in subsequent analysis), a table was constructed so as to summarise the behaviours of each person (MAID) within the data. To

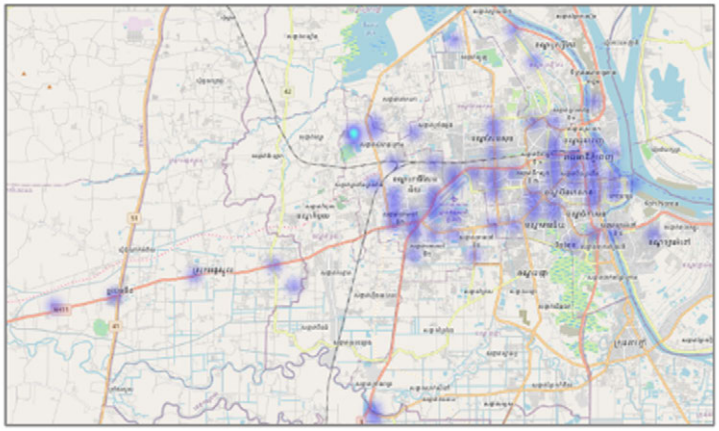
populate this table only "valid" observations were used, following data cleansing and noise removal filtering (as detailed in Sprint 1).

This table **core_maid_summary**, included details for each MAID, indicating:

- average observations per day
- average number of distinct geohash6 locations per day (gh6)
- average number of distinct geohash7 locations per day (gh7)
- average no. consecutive identical (i.e., stationary points) per day (**static points**)
- average distance travelled per day
- total observations contributed

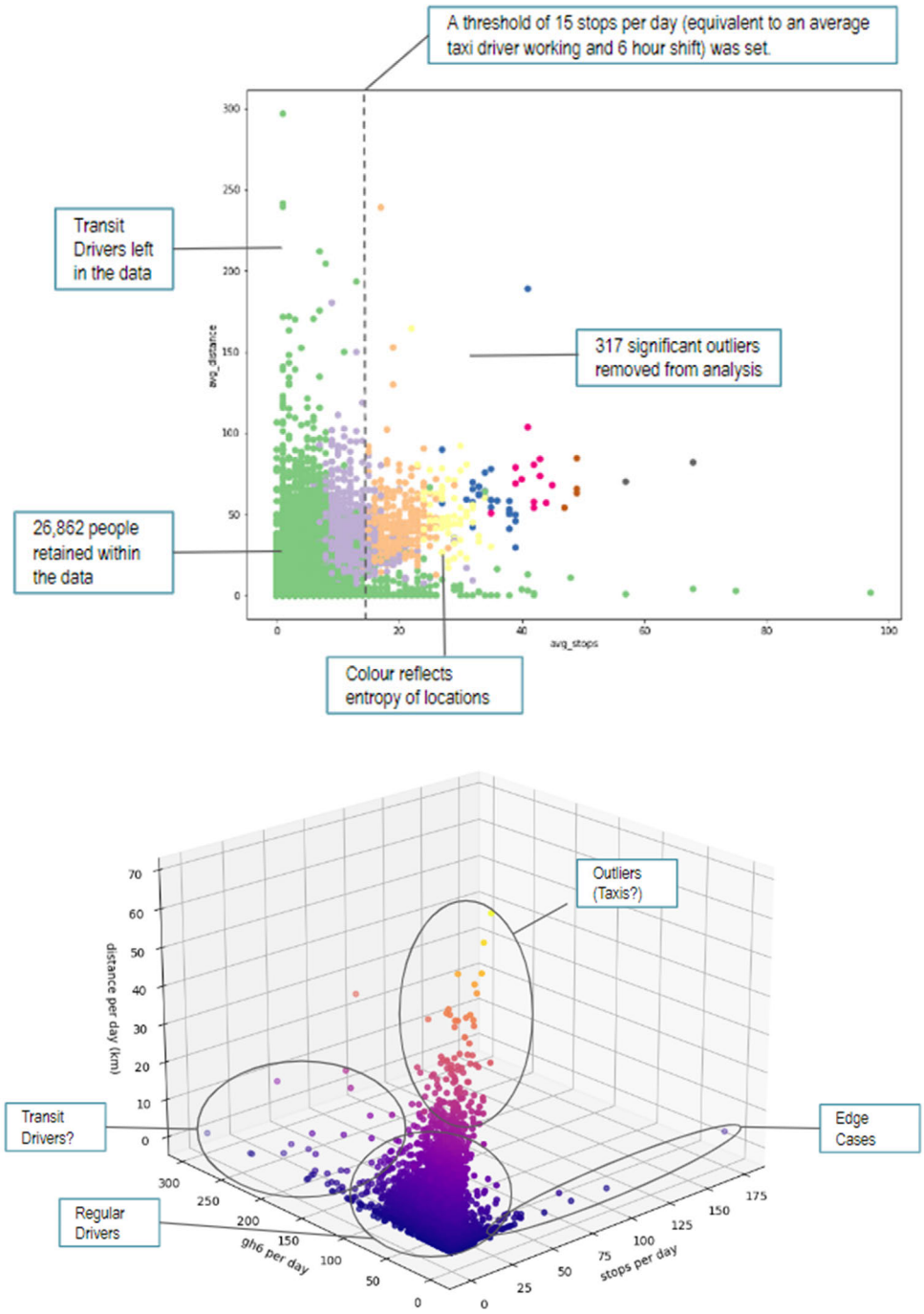
Once collated, it was possible to analyse group behaviours in order to isolate participants thought to be producing atypical data patterns (e.g., taxi drivers / delivery drivers - see Figure 2.2.4 for an example). It was noted that the excess data produced by this minority of MAIDs is likely due to their increased/continual use of apps generating sensor outputs (e.g., sat nav/grab/etc).

Analysis indicated that setting a threshold of 15 stops per day (equivalent to an average taxi driver working and 6-hour shift) would remove high entropy users, most likely taxi drivers (see Figure 2.2.5)



Source: JST

Figure 2.2.4 Examples of Stop-map for Randomly Selected Outlying MAIDs



Source: JST

Figure 2.2.5 Examples of Methods Utilised to Explore Identification of Outlying MAIDs

(5) Sprint 2b. GPS Error / False Movement Correction

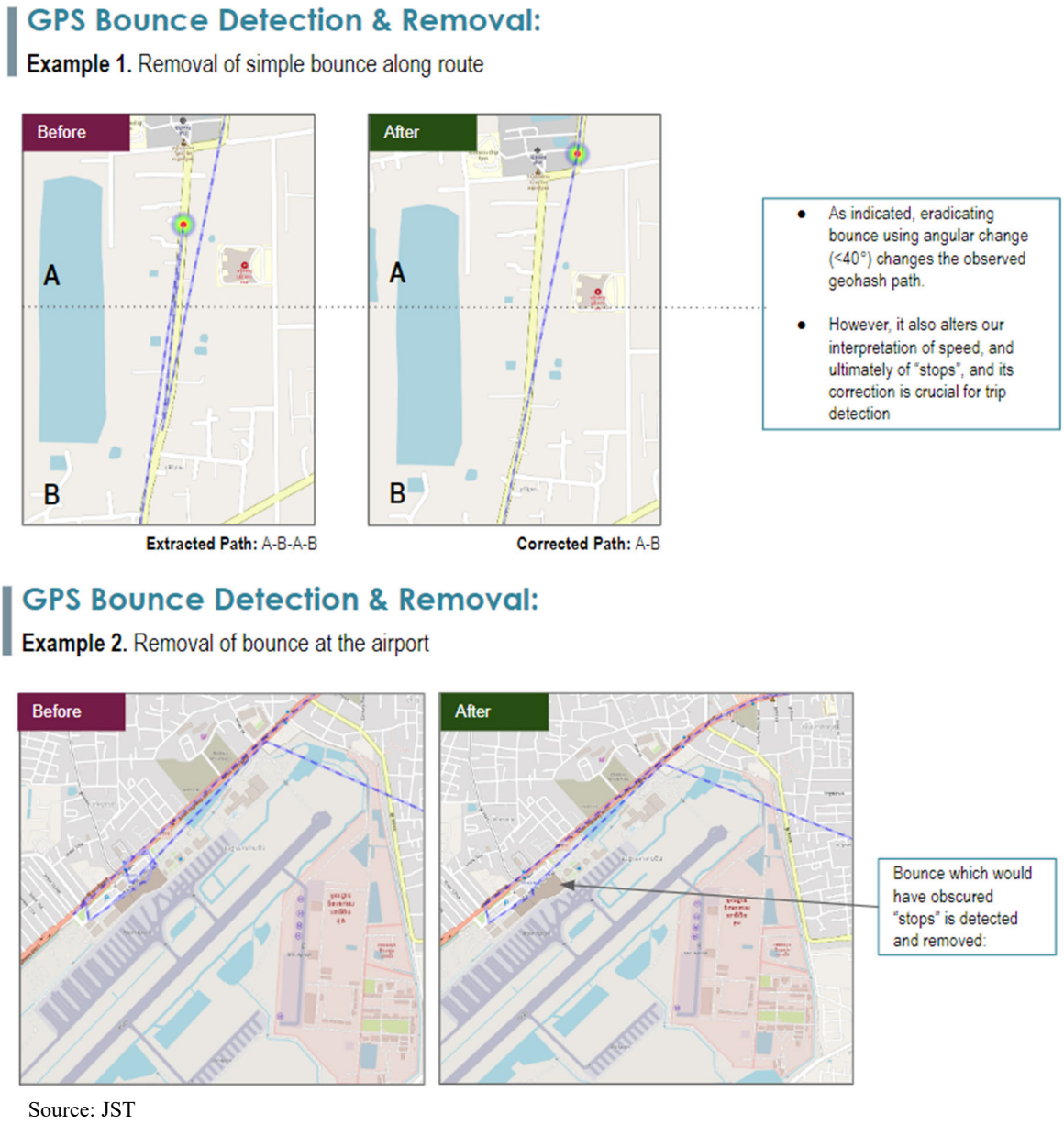
There are numerous ways in which spurious readings can occur in mobile device generated locational data, one of the most significant being GPS "bounce". These are data points which do not follow the underlying trajectory (or stationarity) of the individual, occurring due to significant errors in GPS readings that occur from "bounce" off walls, ceilings, and buildings, common in urban canyons and city settings. These are key to remove algorithmically given their propensity to generate "false trips" with OD matrices especially

when they occur on geohash boundaries - (e.g., as shown in Example 1 of Figure 2.2.5)

It had been already evidenced that GPS bounce, especially common in urban contexts, tends to manifest itself as contiguous points occurring at very acute angles. An algorithm was derived to ensure any points reflecting such acute angles would be filtered. To achieve this:

- i. Points were labelled as GPS bounce if the angle between the previous and next point is ≤ 40 degrees
- ii. Once all data was analysed, GPS bounce points were removed from the data.
- iii. Labelling was then repeated on the newly filtered dataset, and removal again undertaken.
- iv. This process was repeated until convergence was achieved (i.e., no new points are removed).

Figure 2.2.6 shows two examples of GPS bounce removal, which can cause erroneous trips (false movement) and cause valid stops to be missed.



Source: JST

Figure 2.2.6 Two Examples of GPS Bounce Removal

(6) Sprint 3a: Stop Sequence Generation

With data fully cleansed and summarised, outliers labelled, and overall validity hand checked, the next step is stop-sequence generation. This involved parsing of the filtered data to produce a stream of start and end points for Trips.

1) Stop / Trip End-point Identification

While “static points" were used earlier in this analysis for outlier detection and filtering reflecting two consecutive datapoints with the same location attached to them, to detect “true” trip start and end points, a more complex definition of stops is required. The process for identifying **stops** in the MLR data proper is described below.

Note that GPS cannot be used directly due to the sporadic nature of sensor readings, and the random usage patterns of mobile device apps by the users generating underlying data. A distributed python script was hence used to isolate each MAID and convert its individual location points into a sequence of valid ‘stops’.

A stop is defined as a set of at least **k** contiguous events which are all recorded at the same location (geohash6) over a period longer than duration, **d**. The maximum gap, **g**, between events (known as the max_inter_event_time) is also specified (Note that hours between 1am and 6am are not included in this gap time as they reflect sleeping periods where minimal network activity occurs). The parameterisations used in the Phnom Penh analysis are listed in Table 2.2.1 below.

Table 2.2.1 Parameterisation of Stop Identification Process for Mobility Analysis

Item	Symbol	Value	Description
minimum number of events	k	2	The minimum number of consecutive events required within a given region for the segment to be considered a stop.
minimum permissible duration	d	5 mins	The minimum permissible duration between the maximal and minimal times of a set of events with the same geohash to consider them a stop.
maximum inter-event gap	g	4 hours	The maximum time between any two network events before they are considered to be non-consecutive events due to the high probability of unobserved movement.

Source: JST

2) Confidence Assessment:

All stops identified were committed to an SQL table called **stop_id_pp_5min** (representing stops identified within Phnom Penh, with a minimum duration of at least 5 minutes). Stops were assessed against a value representing confidence in each stop’s efficacy.

(7) Sprint 3b: Stop Classification / Metadata Labelling

It was originally specified that stops could be simply classified via HOME / WORK / OTHER via a direct lookup (with entries in the **people** table indicating HOME and WORK geohash6 entries) Unfortunately, there were minimal crossover in MAIDs across mobility and people tables - and no crossover whatsoever in the second data (Version 2). Following filtering the baseline datasets containing valid mobility information for OD matrix generation consisted of 43,245 MAIDs. However, for these:

- 17,746 MAIDs were missing a HOME location (683 from Version 1 data).

- 17,795 MAIDs were missing A WORK location (732 from Version 1 data)

Furthermore, those MAIDs for which direct HOME/WORK labels did exist were heavily biased to 2019 data, restricting analysis of pre- and post-COVID mobility.

To determine journey types (e.g., commutes) it was crucial for the analysis to label all MAIDs wherever possible. As such automatic inferring of HOME and WORK locations was added for the analysis.

1) Day/Night Mode Detection

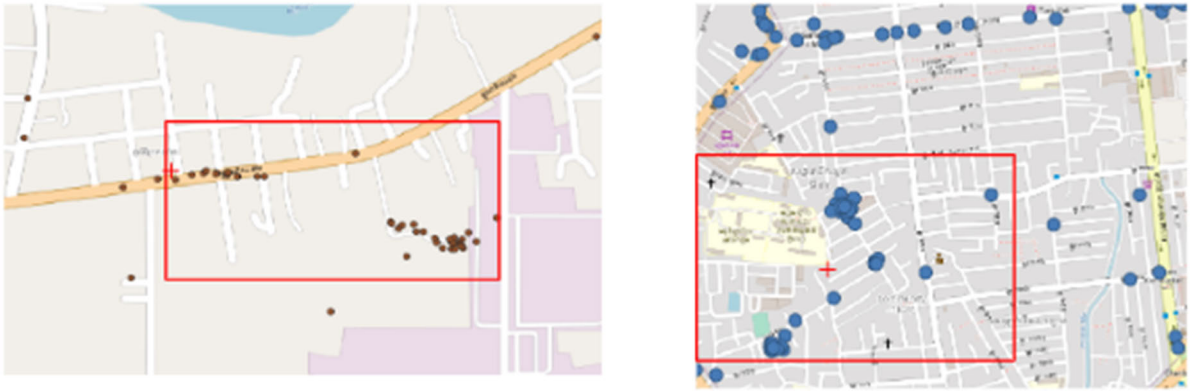
To identify Home/Work locations the most frequent geoshash6 location points were identified for each MAID cleansing in previous stages - i.e., the locations in which they were observed to stop most frequently. This was undertaken for both night and day periods, along with derivation of accompanying statistics that would support confidence assessment. The periods examined were:

- The span reflecting day periods was: 10am - 2pm
- The span reflecting night periods was: 7pm - 3am

Example night and daytime modes are shown in Figure 2.2.7. Once identified, the Day mode and Night mode for each MAID were recorded, alongside:

- the support for that mode (i.e., number of stops seen at that geohash6)
- the entropy of geohash6 cells observed for that user (reflecting "stability" of the modes found).

Note that for recording the second of these statistics (entropy) for night times, the period between 10pm - 3am (rather than 7pm - 3am) was used because earlier evening hours reflect a time period where people are still more active, which adds noise to the detection of the most stable location. This was not used to find the night mode, to ensure that in the mode calculation as much data was included as possible.



Source: JST

Figure 2.2.7 Example of Day and Night geohash6 Modes for Two Individuals

2) Home / Work Filtering:

Once modes had been obtained for each MAID, they were assessed via a filter for both accuracy and stability, to deduce whether they were acceptable estimations of HOME/WORK locations. Those which did not meet a sufficient threshold of observations, or whose normalised entropy[1] (essentially their

[1] Normalised entropy provides an indication that the MAID didn't settle in one place for the majority of their time and therefore it was not possible to predict that the most common location was their home/work cell with sufficient confidence.

variance in geohash6 location) was too high and were removed to ensure coherence in labelling results. The thresholds used are listed in Table 2.2.2.

A further "taxi-filter" was also applied to ensure any outliers to have slipped through the previous anomaly detection filters were precluded, the filter removing work/home locations for any MAID that made more than 3 trips to the airport in any day (or more than 15 trips per day on average).

Table 2.2.2 describes the parameterisation of the day and night mode identification process for HOME/WORK location tagging

Table 2.2.2 Parameterisation of Day and Night Mode Identification Process for Home/Work Location Tagging

Item	Symbol	Value	Description
min observations	o	3	The minimum number of observations of the individual at the designated mode geohash6.
maximum normalised entropy	H	0.8	A representation of the spread of geohash6 stops used by a MAID over the specified period. A high entropy means the individual is seen at a higher variation of location cells, which in this instance is undesirable as it has less confidence as to *which* is the person's true home or work location.
Mean trips per day	T	15	The mean no. of trips per day deemed to be acceptable, above which is considered indicative of taxi / bus driver behaviours
maximum airport trips in any day	A	3	The maximum no. of trips to the airport acceptable, again indicative of taxi / bus driver behaviours
Day span	D_{span}	10.00 - 14.00	The daily period examined when calculating the day mode of an individual MAID, from their observed location stream
Night Span (for mode)	N_{span_m}	19.00 - 03.00	The daily period examined when calculating the night mode of an individual MAID
Night Span (for entropy)	N_{span_e}	22.00 - 03.00	The daily period examined when calculating the night mode of an individual MAID

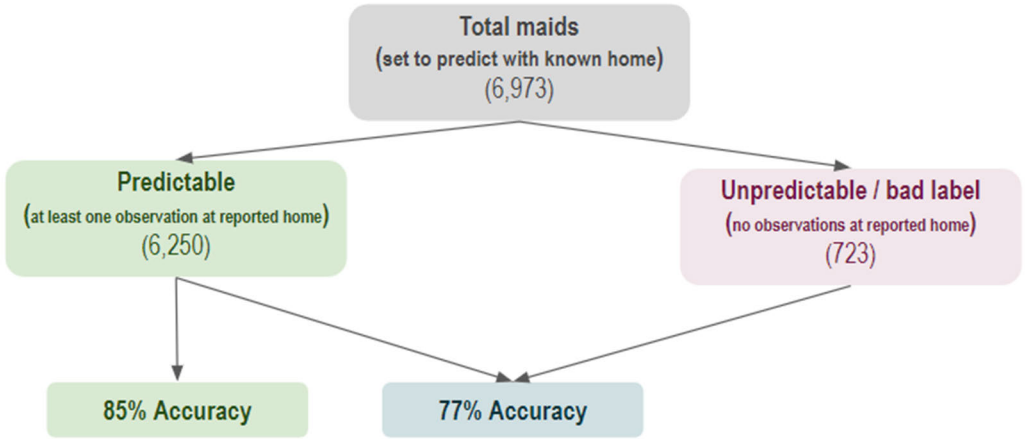
Source: JST

3) Assessment:

To both assess and fine tune the setting of each parameter, the home/work labelling algorithms were optimised against MAIDs for which there existed a "ground-truth" (i.e., MAIDs from the first data, which had labels for their "true" home and work locations listed in the people table). From this validation process it was evident that for those MAIDs that were at all predictable (i.e., MAIDs for which there was any location data reflecting their reported Home/Work):

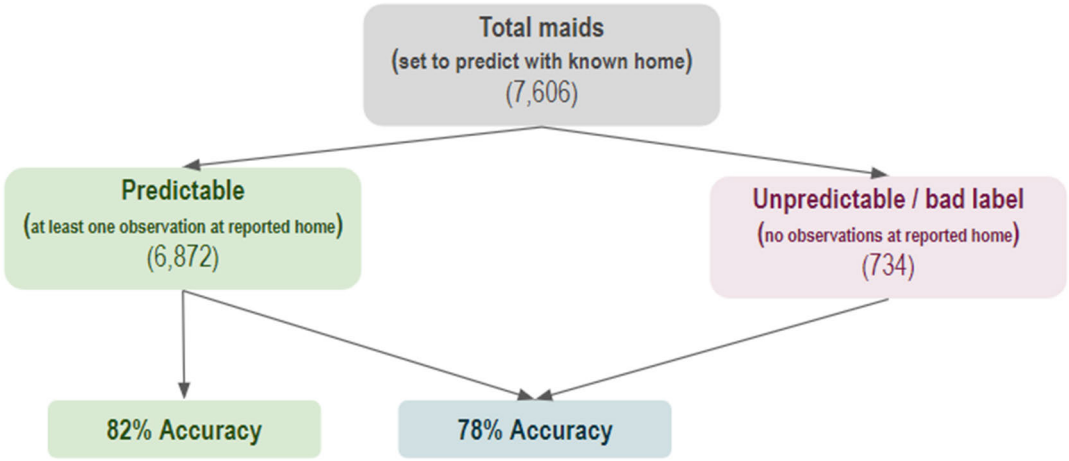
- i. a correct estimation of Home location was made with 85% accuracy.
- ii. a correct estimation of Work location was made with 82% accuracy.

This process is illustrated in Figure 2.2.8 and Figure 2.2.9 respectively.



Source: JST

Figure 2.2.8 Assessment of Home geohash6 Prediction Algorithm



Source: JST

Figure 2.2.9 Assessment of Work geohash6 Prediction Algorithm

4) Aggregation:

Once the process was implemented, it became possible to visualise the distribution of residences and workplaces across the extent.

(8) Sprint 3c: Trip Database Construction

1) Trip Identification:

Stop sequences were then converted into a set of trips for each MAID. A trip is formally defined as 2 contiguous 'stops' that are separated by a period of at least t_{min}, but no more than t_{max}. The value for t_{min} ensures that false movement has not slipped through the net (a double check of the GPS bounce issue discussed previously). Setting t_{max} ensures that it is unlikely that a trip that, in actuality, is missing a midpoint destination has been reconstructed.

Table 2.2.3 describes the parameterisation of the trip identification process for mobility analysis.

Table 2.2.3 Parameterisation of Trip Identification Process for Mobility Analysis

Item	Symbol	Value	Description
minimum trip duration	t_{min}	0 mins	The minimum permissible duration between the maximal and minimal times of a set of events with the same tower_id to consider them a stop. Given the data has a high sampling rate (as it is app/gps vs. CDR), this parameter should be and was set to zero[2].
maximum trip duration	t_{max}	5 hours	The maximum time between any two events before they are considered to be non-consecutive events due to the high probability of unobserved movement.

Source: JST

2) Trip Labelling:

Finally, trips were labelled (using the labels attached to their start and end-points, based on the MAID generating them) as:

- i. Home Based Work (HBW)
- ii. Work Based Home (WBH)
- iii. Home Based Other (HBO)
- iv. Non Home Based (NBO)

(9) Sprint 4a: Intermediary Origin-Destination Matrix Generation

1) Trip Cleansing:

Prior to development of the final OD matrices (and different version of these, reflecting the inclusion of taxis and am/pm variations) the dataset can be optionally filtered to remove individuals with outlying behaviour (i.e. disproportionately high observation counts, as discussed in Sprint 2a).

It should be recalled these are MAIDs that can radically skew (bias) the representative nature of the results due to the disproportionately large number of trips attributed to them. The thresholds for outlying behaviour, (15 trips on average per day) is of course subjective, despite being selected due to the exploratory analysis. As such, and to augment this, a further filtering stage was added at this point, following observation that outlying MAIDs showed a strong frequency at geohashes with transport hubs. Hence MAIDs were also tagged for removal when:

- i. Observed making stops at an Airport geohash > 3 times in a day
- ii. Observed making > 15 trips on average per day

2) Trip Aggregation:

Once appropriate filtering had been applied (all/non-outlier/am/pm) all MAID information was removed, and a union taken of all sets of trips constructed. This produced our entire trip database for subset being examined.

[2] This is due to the fact that a stop is identified using the entry and exit timestamps into the geohash6. As such a trip duration (if location is continuously recorded which it often is in this data set) is measured from the exit of the origin region to the entry of the destination region. In the case a trip is between two neighbouring regions then the trip duration will be, by definition, almost zero. The high confidence able to be attributed to the stop identification phase due to the vastly increased number of samples app/gps data contains vs CDR data additionally enables the parameter, which is important in a CDR context, to be set in this way.

3) Matrix Generation

From this trip-set a corresponding OD matrix was created (via a process of enumerating the number of trips identified between each geohash). The input trip-set used can also be varied through filtering to allow various forms of analysis as required:

- Time of day
- Day of week
- Year (pre-post COVID)
- minimum trip duration
- minimum trip distance
- Trip purpose (based on work, home or other), etc.

(10) Sprint 4b: Scaling

In order to convert intermediary relative OD matrices into absolute counts representing the whole population of Phnom Penh, a process of scaling ought to then be implemented. This stage was not achievable due to a lack of "ground-truth" data points available to the analysis, but is applicable post-hoc when such datasets become available.

(11) Sprint 4c: Reporting, Packaging and Final OD Output generation

1) Representation:

Two different geospatial resolutions were considered, geohash6 and Phnom Penh traffic analysis zones (TAZ). Trip databases were constructed and delivered for both resolutions while OD matrices were constructed for geohash6 regions with the option to generate OD matrices for TAZ available in the future from the delivered TAZ trip data.

2) geohash6:

Stops were primarily identified based on a geohash6 spatial resolution, with trips derived from the identified stops as detailed above.

3) Phnom Penh Traffic Analysis Zones (TAZ):

Trip start and end points were then assigned to Phnom Penh traffic analysis zones (TAZ) enabling the resulting trip database to be considered with respect to the TAZ spatial resolution. This was achieved by considering all raw GPS points corresponding to each stop and assigning the TAZ that contained the majority of these. This ensured that stops assigned to any geohash6 zones that sat on the boundary of multiple TAZ were correctly assigned.

4) Collation:

A number of different OD maps for each of the geohash grid areas were created. Each analysis visualises representations of:

- inbound trips;
- outbound trips;
- commuting patterns to and from the zonal unit:
- temporal breakdowns;

- summaries of inbound traffic from external regions;
- impact on transport flows via routing densities.

2.2.2 Results

(1) Raw Data Analysis

Table 2.2.4 Dataset Overview

DATASET	PERIOD	MOBILITY TABLE	PEOPLE TABLE
DATASET Version 1	01-31 Jan 2020 01-31 Jan 2021	148,596,267 rows 212,067 MAIDs	475,333 rows 475,273 MAIDs
DATASET Version 2	01-31 Jan 2020 01-31 Jan 2021 01-31 Mar 2022	152,248,405 rows 349,492 MAIDs	n/a

Source: JST

1) Temporal Distribution

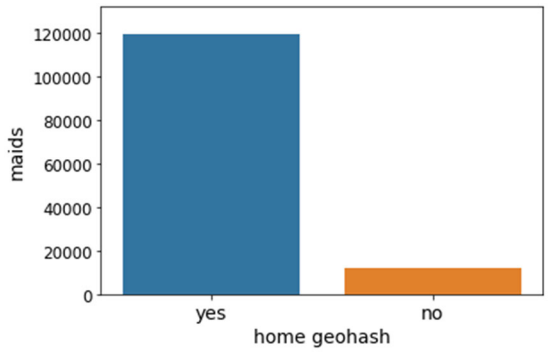
Table 2.2.5 Temporal Distribution

PERIOD	SIZE	INDIVIDUALS RECORDED
JAN 2020	96,041,202 rows	84,320 distinct MAIDs
DEC 2020	2,461,833 rows	23,076 distinct MAIDs
JAN 2021	50,093232 rows	134,927 distinct MAIDs
MAR 2022	3,651,705 rows	144,465 distinct MAIDs
APR 2022	433 rows	128 distinct MAIDs

Source: JST

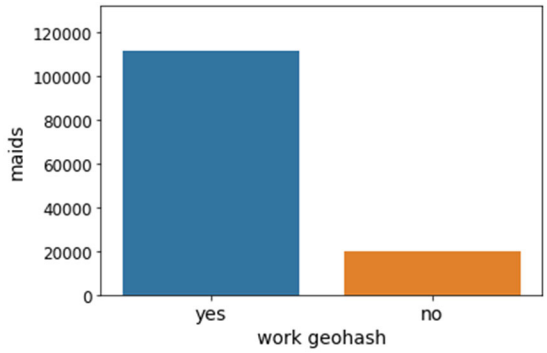
2) Home/Work Locations

91% of people (MAIDs) for whom mobility logs were supplied in the Version 1 dataset were accompanied by a home location geohash identifier (See Figure 2.2.10). 84% of people for whom JST had mobility logs were identified in by a single work location geohash identifier in the supplied data (See Figure 2.2.11).



Source: JST

Figure 2.2.10 Identification of Home Locations

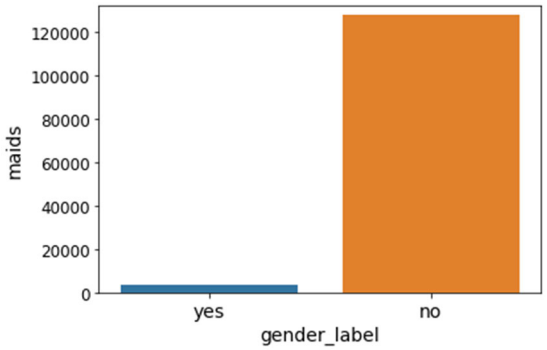


Source: JST

Figure 2.2.11 Identification of Work Locations

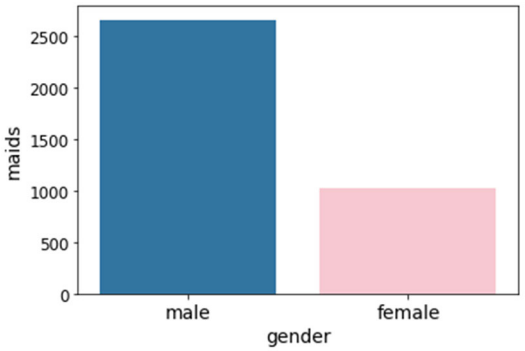
3) Gender Information

Gender Information is highly sparse. Only 2.8% of people in the dataset had a gender attached to them (See Figure 2.2.12). Of the few MAIDs the gender did exist for 74% are male and 26% are women (only 1023 people in total) as shown in Figure 2.2.13.



Source: JST

Figure 2.2.12 Identification of Genders

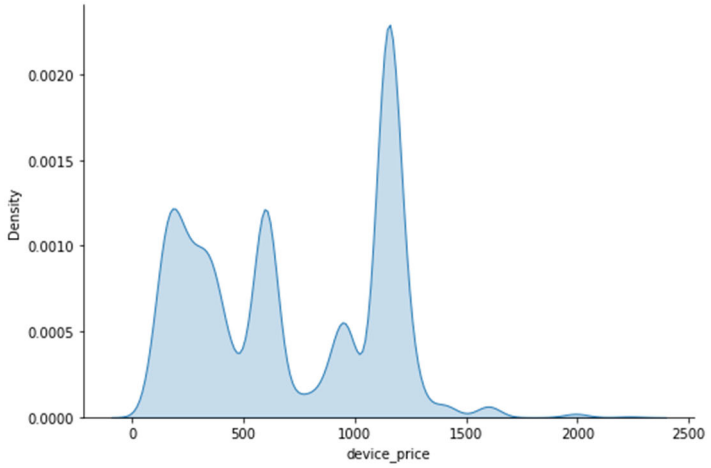


Source: JST

Figure 2.2.13 Gender Distribution

4) Device Pricing

Less than 15% of devices have age information attached to them, making the field likely redundant for the analysis. However, as shown in Figure 2.2.14, slightly more devices in the mobility data have a price attached to them (~24.5%), with a highly varying cost distribution.

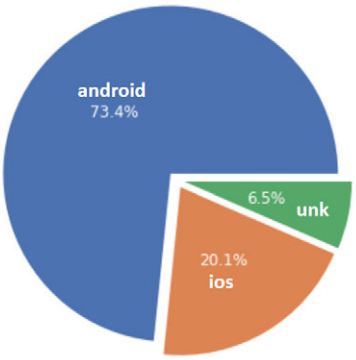


Source: JST

Figure 2.2.14 Device Pricing Distribution

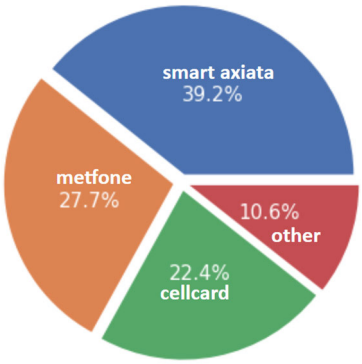
5) Device Information

Operating System (OS) distributions across data points is shown in Figure 2.2.15. Carrier information of devices used in the locational data was also included in the data as shown in Figure 2.2.16. Device types are indicative of expected distributions across the market (See Figure 2.2.17).



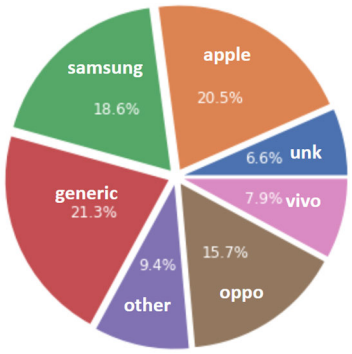
Source: JST

Figure 2.2.15 Operating System Distribution



Source: JST

Figure 2.2.16 Carrier Distribution

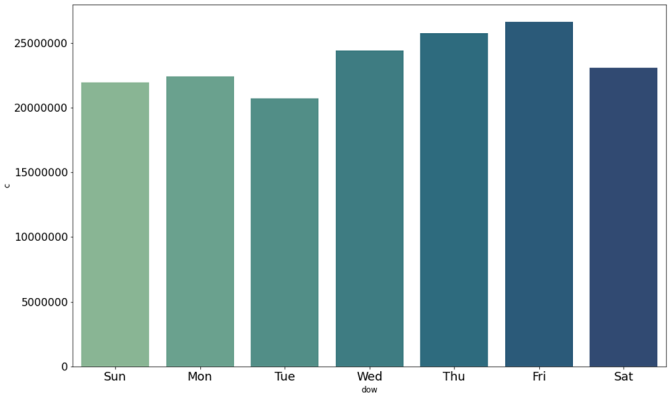


Source: JST

Figure 2.2.17 Device Type Distribution

6) Observations per Day

As illustrated in Figure 2.2.18, observations from the mobility table are spread relatively evenly over days of the week in the raw data set. This is somewhat surprising, given within urban analyses one would expect to see increased movement across weekdays. This may be related to the previously identified bias within the data.

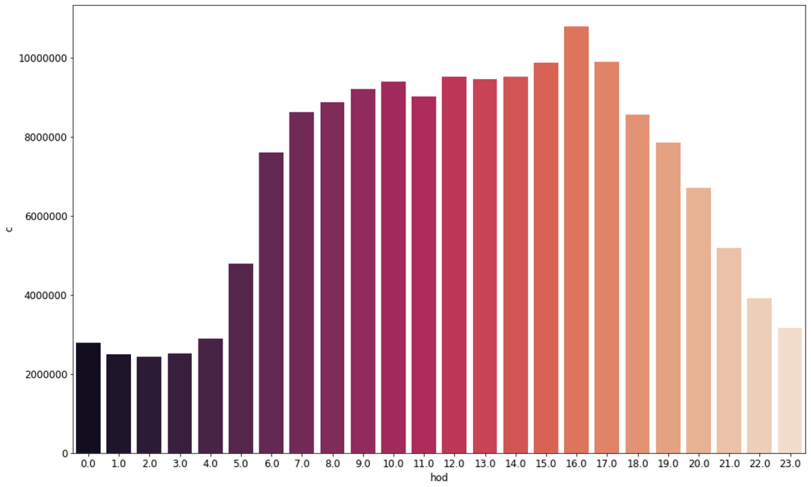


Source: JST

Figure 2.2.18 Observations per Day

7) Observation per Hour

As expected, there are less data in the evening periods 19:00 to 21:00 and overnight periods 22:00 to 05:00 as shown in Figure 2.2.19. As common in many urban analyses, there is a spike at 17:00. Morning rush hour periods however are not noted. Nor is the traditional dip in late morning/afternoon periods.

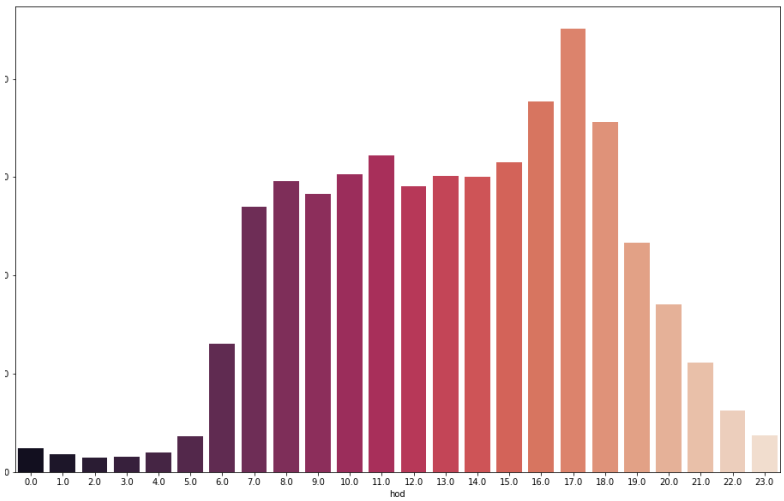


Source: JST

Figure 2.2.19 Observations per Hour Pre-filtering

This unexpected distribution was of concern and hence a detailed filtering step was taken (see Methodology). Following filtering for a range of factors, including sensory accuracy, and outlying behaviour such as taxis, the following adjusted distribution resulted as shown in Figure 2.2.20:

As expected there remains less data in the evening periods 19:00 to 21:00 and overnight periods 22:00 to 05:00 following filtering. Morning and early evening rush hour periods are more notable. However, the number of observations in morning periods is still lower than expected.



Source: JST

Figure 2.2.20 Observations per Hour Post-filtering (Without TAXIs)

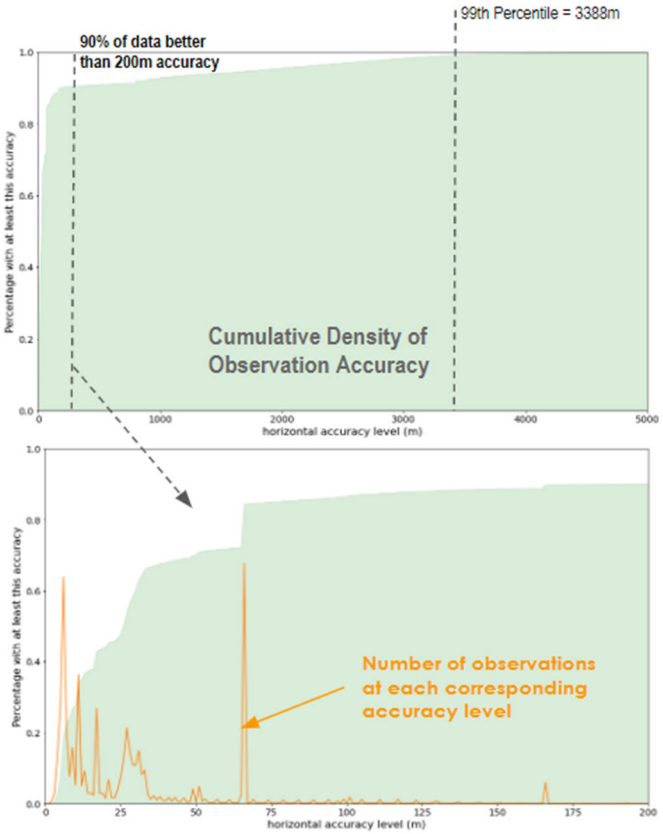
8) Observation Accuracy

The MLR data used in this analysis was accompanied by some "accuracy" fields, such as "horizontal accuracy", allowing JST to filter analysis to datapoints that had a greater precision.

Of the 164 million observations:

- Range: 0 m to 4,337 km
- Mean accuracy: 416 m
- Median accuracy: 16 m
- 90th percentile: 190 m
- 99% percentile: 3,388 m

Almost all information is supplied at reported accuracy levels of less than 70 m, but with a notable spike at 68 m, after which data points drop off significantly. In general, Wi-Fi generated data points are actually frequently more accurate than GPS at lower resolution levels within the dataset.

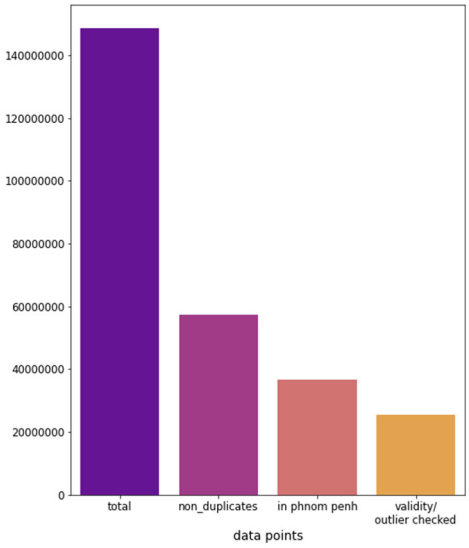


Source: JST

Figure 2.2.21 Sensor Accuracy

9) Utilisable Data

A range of causes render many data points supplied the analysis spurious or non-useable. Figure 2.2.22 and Table 2.2.6 describe the data reduction and its causes.



Source: JST

Figure 2.2.22 Data Reduction due to Filtering

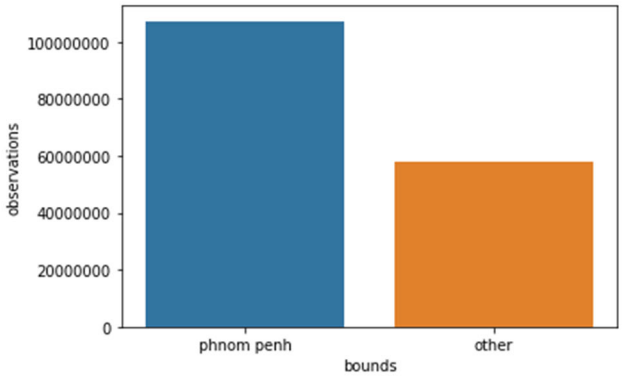
Table 2.2.6 Data Reduction due to Filtering

Cause of Filtering	Size
Duplicate data point	91,295,203 records
Spurious speed (negative or null)	17,957,575 records
Insufficient locational accuracy (> 2 km)	17,266,401 records
Spurious inter-point speed (indicating "bounce") (> 35 m/s)	2,149,044 records
longitude / latitude outside of Cambodia	105,471 records
Excessive declared speeds (> 35 m/s)	12,198 records
Spurious GPS accuracies (negative)	290 records

Source: JST

10) Data Coverage

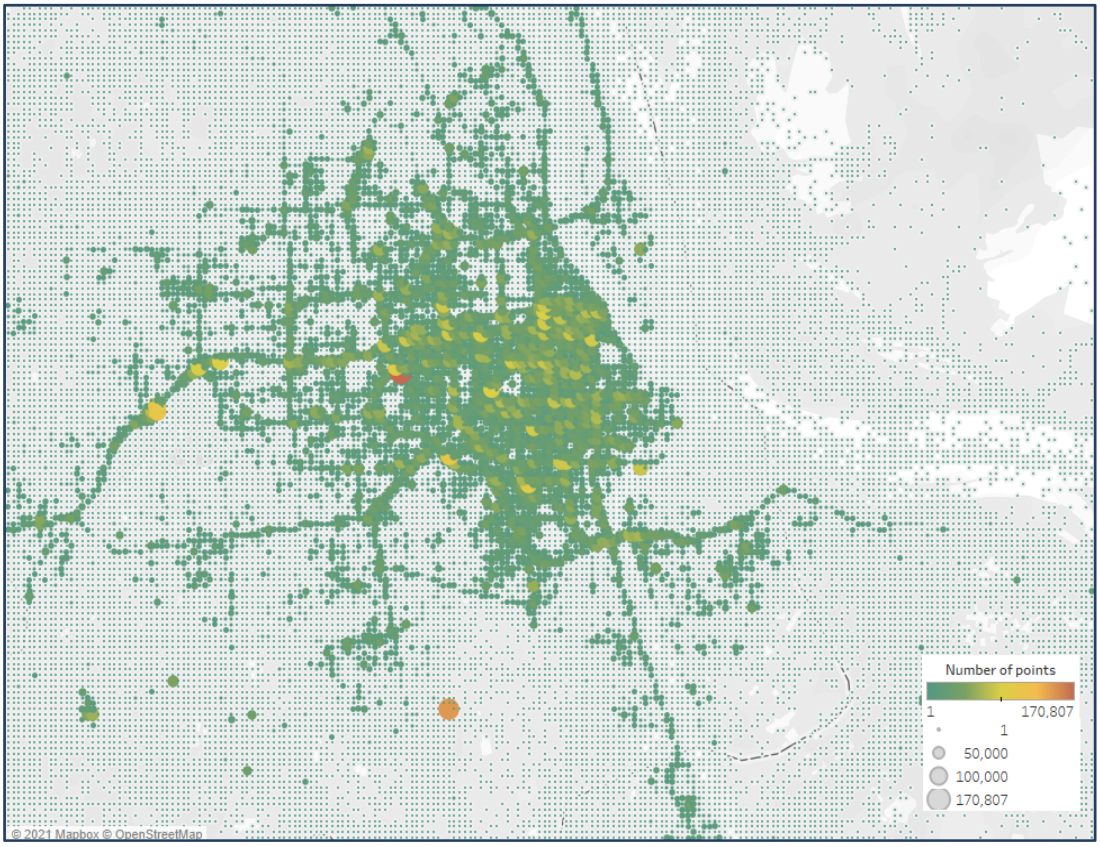
The number of data points both internal and external to Phnom Penh, indicate the wide support available for movement within the city. The majority of the observations supplied were located within city bounds, with ~65% of the data housed in the mobility table referencing positions within the extent of Phnom Penh.



Source: JST

Figure 2.2.23 Data Coverage in Phnom Penh

This is further emphasised by a map of the coverage of Location Readings in the mobility table across the extent of Phnom Penh, with the highlighting of road infrastructure that occurs simply by plotting the data indicating the likely use of apps during transport (See Figure 2.2.24).



Source: JST

Figure 2.2.24 Distribution of Data Points

(2) Preliminary Trip Database Summaries

1) Summary Tables

Table 2.2.7 All Individuals

Feature	ALL DATA	2020	2021
Total Trips Detected	1,152,410	757,579	370,454
Total MAIDS with Trips	30,464	17,146	13,002
Mean Trips per MAID	37.83	44.18	28.49
Min	1	1	1
Max	1186	769	462
Variance of Trips per MAID	4101.25	3717.85	1779.60

Note: The difference between figures for 2021 and 2022, in comparison to the total, is due to sparse data included from 2022.

Source: JST

Table 2.2.8 Without Outliers/Taxis:

Feature	ALL DATA	2020	2021
Total Trips Detected	649,082	396,094	233,222
Total MAIDS with Trips	26,012	13,493	11,282
Mean Trips per MAID	24.95	29.36	20.67
Min	1	1	1
Max	450	367	223
Variance of Trips per MAID	1530.48	1395.85	826.03

Source: JST

Table 2.2.9 Without Outliers/Taxis and Trip Durations (tmax) < 5 hours

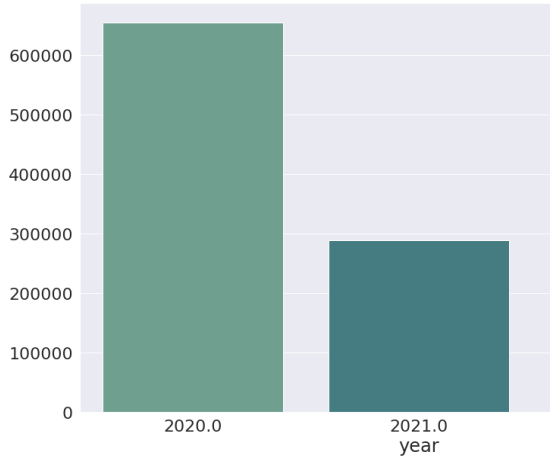
Feature	ALL DATA	2020	2021
Total Trips Detected	626,318	385,518	224,063
Total MAIDS with Trips	24,335	13,073	10,767
Mean Trips per MAID	25.74	29.49	20.81
Min	1	1	1
Max	448	367	223
Variance of Trips per MAID	1578.36	1410.98	844.50

Source: JST

2) Home / Work Locations

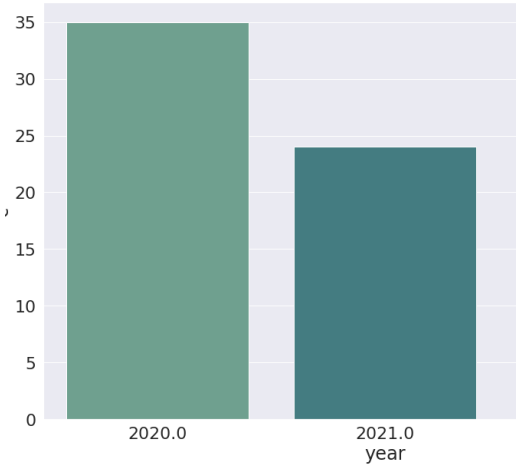
Total trips detected by year notably decrease between 2020 and 2021 as shown in Figure 2.2.25, likely as a consequence of the pandemic / government policy / lockdown requirements. However, all inferences made must be taken in light of potential biases introduced by sampling in the MLR datasets feeding into this analysis (for which the data provider is unable to transfer full details). It was noted further that data for 2022 is not shown, due to extreme sparsity of datapoints within individual MAIDs rendering trip detection far lower. This is likely an artefact of the sampling of the 2022 dataset by the data supplier.

Trips detected per person by year in Figure 2.2.26 indicate a very similar result, with an even starker drop in detected journeys.



Source: JST

Figure 2.2.25 Total Trips Detected by Year



Source: JST

Figure 2.2.26 Trips Detected per Person by Year

3) Trip Purposes

Table 2.2.10 All Individuals Including Trips of All Durations for Maximum Coverage

Purpose	ALL DATA	2020	2021
Home to Work	16,598 (44,145*)	12479 (28,513*)	3,783 (14,780*)
Work to Home	15,704 (43,251*)	11060 (27,094*)	4,353 (15,350*)
Home to Other	145,890	84,488	58,820
Other to Home	147,159	86,418	58,006
Other to Other	300,168	160,140	133,531

* = an asterisk represents figures which include situations where an individual's work and home geohashes are the same, hence representing potential trip purposes. Raw figures indicate situations where this is not the case, so trip purpose is more certain.

Source: JST

4) Weekday Breakdowns

Table 2.2.11 shows trips with weekday breakdowns excluding taxis, omitting individual's for which the home location was the same as the work location.

Table 2.2.11 Weekday Breakdowns of Trips

Purpose/ Day of Week	Any	Home to Work	Work to Home	Any to Home	Any to Work	Home to Any	Work to Any
Mon	15.68% (19885)	14.71% (1858)	14.91% (1740)	13.8% (4149)	14.54% (4227)	13.71% (4089)	14.49% (4125)
Tue	16.49% (20912)	14.53% (1836)	14.89% (1738)	13.81% (4151)	14.25% (4142)	13.58% (4050)	14.38% (4094)
Wed	16.62% (21078)	16.57% (2094)	16.67% (1946)	16.05% (4824)	16.15% (4693)	15.6% (4650)	16.28% (4633)
Thurs	12.85% (16298)	17.93% (2265)	17.64% (2059)	16.34% (4913)	17.56% (5104)	16.32% (4867)	17.6% (5008)
Fri	10.69% (13560)	17.53% (2215)	17.38% (2029)	16.55% (4975)	16.97% (4932)	16.73% (4988)	17.18% (4891)
Sat	14.09% (17871)	11.86% (1498)	11.22% (1310)	12.78% (3841)	11.79% (3426)	13.51% (4028)	11.49% (3271)
Sun	13.58% (17217)	6.87% (868)	7.28% (850)	10.67% (3208)	8.75% (2543)	10.55% (3145)	8.57% (2440)

Source: JST

(3) Origin Destination Matrices

The developed data as a SQLite database contains the following:

- 1x full (raw) trip table
- 42x OD matrices, one table per matrix

1) Full (Raw) Trip table:

The raw trip table is used to generate OD matrices. It includes taxis and all trips regardless of duration and is **unfiltered** with respect to t_{min} and t_{max} as discussed previously. These filters are applied to create a (temporary) trip database while constructing the OD matrices.

Table 2.2.12 Description of Full (Raw) Trip Table

Field	Type	Description
maid	TEXT	The MAID associated with the trip
journey_start_geohash6	TEXT	The trip start location (Spatial representation: geohash6)
journey_start_taz2022	NUMBER	The trip end location (Spatial representation: TAZ)
journey_end_taz2022	NUMBER	The trip end location (Spatial representation: TAZ)
journey_end_geohash6	TEXT	The trip end location (Spatial representation: geohash6)
journey_start	DATETIME	The date and time the trip was identified as started
journey_end	DATETIME	The date and time the trip was identified as ended
journey_duration_in_min	BIGINT	The length of the trip in whole minutes
istaxi	BOOLEAN	True if the trip was inferred to be a taxi, False otherwise
taz_home	NUMBER	The provided or inferred home location for this MAID (Spatial representation: TAZ)
taz_work	NUMBER	The provided or inferred work location for this MAID (Spatial representation: TAZ)
geohash6_home	TEXT	The provided or inferred home location for this MAID (Spatial representation: geohash6)

Field	Type	Description
geohash6_work	TEXT	The provided or inferred work location for this MAID (Spatial representation: geohash6)

Source: JST

2) OD Matrices

Finally, the 42 OD matrices were created, representing filtered OD matrices of all combinations of the items in Table 2.2.13.

Table 2.2.13 Filtered OD Matrices Overview

Trip from origin to destination	Trip made during	MAID type
any origin to any destination home to any destination work to any destination any origin to home any origin to work home to work work to home	AM PM Any time	any, including taxis any, excluding taxis

Source: JST

Each was delivered as a SQLite table of which details are summarised in Table 2.2.14.

Table 2.2.14 Data Description of OD Matrices

Field	Type	Description
origin	TEXT	The geohash6 representation of the origin (any destination, home or work) as noted in the table name.
destination	TEXT	The geohash6 representation of the destination (any destination, home or work) as noted in the table name.
trip_count	NUMBER	The absolute number of trips identified as being taken during the temporal period
trip_percent	NUMBER	The proportion of trips (after filtering) this represents

Source: JST

2.3 Basic Unit of Evaluation

2.3.1 Basic Unit of Vehicle Operating Cost

Basic unit of Vehicle Operating Cost (VOC) for each vehicle type is shown below.

Table 2.3.1 Basic Unit of Vehicle Operating Cost by Vehicle Type

Speed	Motorcycle	Paratransit	Car	Bus	Truck
0-10 km/h	129	129	713	852	1,139
10-20 km/h	76	76	422	508	672
20-30 km/h	47	47	268	330	432
30-40 km/h	43	43	244	300	393
40-50 km/h	33	33	185	240	272
50-60 km/h	30	30	170	236	252
60-70 km/h	30	30	169	250	247
70-80 km/h	31	31	174	271	256
80-90 km/h	32	32	180	296	277

Unit: USD/veh-1000km

Source: JICA Study Team (2020) “Preparatory Survey for Phnom Penh Urban Railway Development Project”

2.3.2 Values for CO_2 Emission Factors

For CO_2 emission factor per passenger kilometre for each transport mode is shown in the table below.

Table 2.3.2 Default Values for CO_2 emission factors

Mode	Value (t-CO_2 / passenger-km)
Tuk-tuk	0.000030
Bus	0.000025
Bike	0.000050
Passenger Car	0.0001025

Source: JICA Study Team (2020) “Preparatory Survey for Phnom Penh Urban Railway Development Project”. CO_2 emission factor per passenger kilometre for tuk-tuk is set based on the factors in other countries like India and Bangladesh.

Original Source: Based on Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities (GTZ, 2007)

Appendix 3 Reference Information

3.1 Important Bird Area (IBA)

Table 3.1.1 Overview of IBA

Name of IBA Area	Endangered Species	IBA Criteria	Migratory birds?	IUCN Red List Category
Basset Marsh 2,770ha	Darter Anhinga melanogaster	A1	No	NT
	Spot-Billed Pelican Pelecanus philippensis	A1	Yes	NT
	Asian Golden Waver Ploceus hypoxanthus	A1	No	NT
Boeung Veal Samnap 11,286ha	Darter Anhinga melanogaster	A1	No	NT
	Black-headed Ibis Threskiornis melanocephalus	A1	Yes	NT
	Spot-Billed Pelican Pelecanus philippensis	A1	Yes	NT
	Painted Stork Mycteria leucocephala	A1	No	NT

NT: Near Threatened

IUCN: International Union for Conservation of Nature

Source: Directory of Important Bird Areas in Cambodia: key sites for conservation, Department of Forestry and Wildlife et al., 2003 and hearing from BirdLife International Cambodia.

Table 3.1.2 IBA Trigger Species and Criteria

IBA Trigger Species	Criteria
A1 Globally threatened species	The site is known or thought regularly to hold significant numbers of a globally threatened species
A2 Restricted-range species	The site is known or thought to hold a significant component of a group of species whose breeding distributions define an Endemic Bird Area (EBA) or Secondary Area (SA).
A3 Biome-restricted species	The site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome.
A4 Congregations	The site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.

Source: BirdLife International Data Zone, Global IBA Criteria, http://datazone.birdlife.org/site/ibacritglob Accessed on 7 Feb. 2018

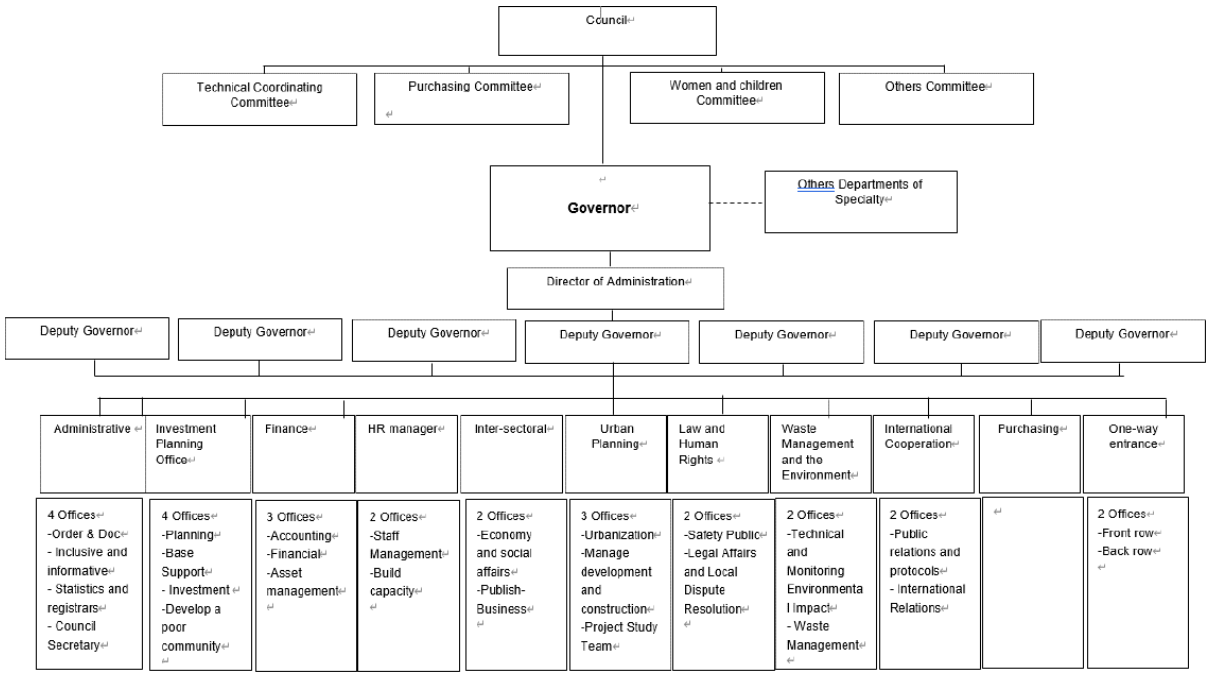
3.2 Organisations

Outline of concern organizations on urban transport in Phnom Penh are summarized as below.

3.2.1 PPCA

1. Name	Phnom Penh Capital Administration
2. Responsibility	- Administering all received letters and documents properly and in accordance with existing laws; - Responsible for all letters and documents prepared by the Phnom Penh Capital council or on behalf of the council and by the Phnom Penh Capital board of governors on behalf of the state as well as the owner of equipment, transport means and materials of its administration.

3. Organization Chart



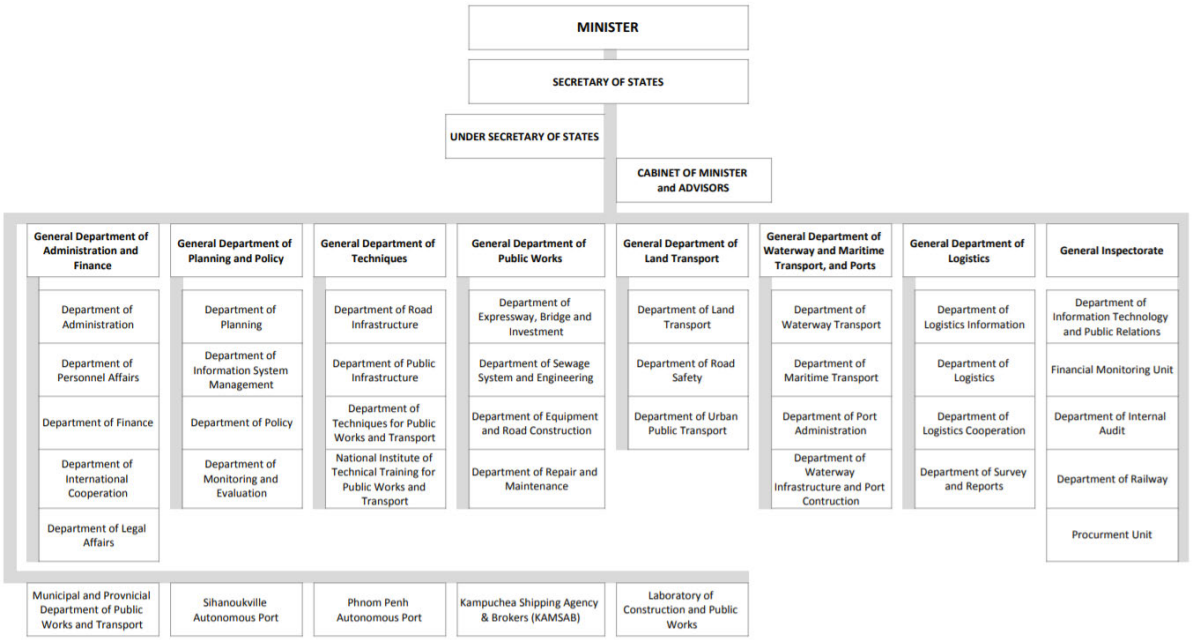
Source: PPCA

4. Responsibility on the Department related to Urban Transport	
Urban Planning	- Cooperation in the formulation of master plan and land-use plan; - Works related to land tenure, construction and reparation of constructions as well as addressing problems related to violations of construction rules; - Formulation of strategy and development for settlement in the Phnom Penh Capital; - Management of old constructions and heritages of the Capital; - Development of transportation infrastructures, parks, gardens and public light facilities.
Planning and Investment Division	- Five (05) year development plan and three (03) year rolling investment program of the Capital; - Management of contracts and/or implementation of projects signed with the Capital administration - Cooperation in feasibility study, preparation of drawings and project proposals for inclusion as part of the Capital development plan and technical support to the Khans and Sangkats on the above tasks; - Support to development plan and investment program formulation process of Khans and Sangkats as well as implementation of Khan and Sangkat projects; - Review legality of Deika and decisions of the Khan and Sangkat councils; - Review and provide recommendations on proposed investments and development projects in the jurisdiction of the Phnom Penh Capital; - Prepare and update data related to development projects of private sector and other stakeholders of the Capital, Khans and Sangkats.

Source: Sub Decree No. 215 ANK/BK dated 14 December 2009 on Roles, Duties and Working Relationship of the Phnom Penh Capital Council and Board of Governors, and the Khan Council and Board of Governors of the Phnom Penh Capital

3.2.2 MPWT

1. Name	Ministry of Public Works and Transport
2. Responsibility	- Managing and developing national policies on general public civil construction sectors through the preparation of principles and laws in collaboration with other institutions to develop the country; - Improving, maintaining, and managing public infrastructures such as roads, bridges, ports, railways, water ways, and state buildings; - developing regulations related to the management of roads, ports, railways, and waterways infrastructures; - developing regulations and managing all road transportations, railways, and waterways; - participating and jointly developing laws, rules, and regulations relating to construction; - renovating buildings as assigned by the Royal Government; - cooperating with the State Secretariat of Civil Aviation on aeronautical constructions.
3. Organization Chart	



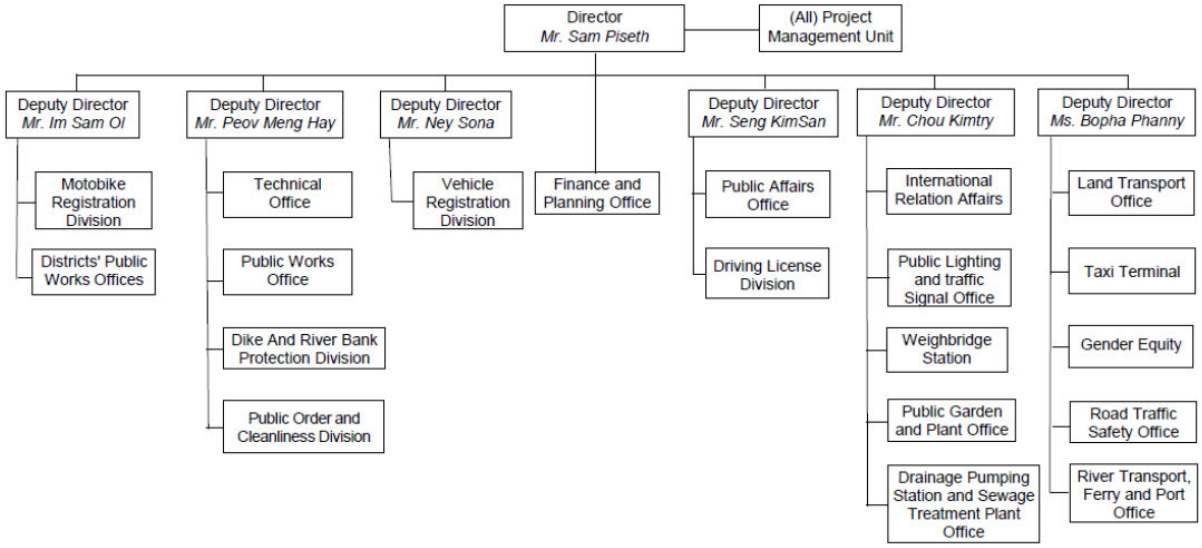
Source: MPWT

4. Responsibility on the Department related to Urban Transport	
General Department of Land Transport	- Directing, managing, and facilitating on the works of land transport. It shall consist of the following 3 departments: 1. Department of Land Transport; 2. Department of Road Safety; **3.** Department of Urban Public Transport.
General Department of Public Works	- Directing, managing, facilitating, monitoring, and supervising on the construction and repair of works, maintenance of public infrastructure, public building, operating of the investment for developing of public works and transport sector. It shall consist of the following 3 departments: 1. Department of Expressway, Bridge and Investment; 2. Department of Sewage System and Engineering 3. Department of Equipment and road Construction 4. Department of Repair and Maintenance

Source: Sub Decree No. 216 ANKR/BK dated 13 October 2016 on Organization and Functioning of Ministry of Public Works and Transport

3.2.3 DPWT

1. Name	Department of Public Works and Transport
2. Responsibility	- Representing the ministry for in charge of implementing of the government strategy on public works and transport at provincial – municipal level; - Managing of administrative works, and preparing capacity building plan for officers under DPWT; - Managing and controlling for all transport works includes transport means, parking space, and the site for repairing, costuming and assembling of those means of transportation according to the ministry specification; - Managing and maintaining transportation infrastructure such as roads, bridges, ports (except Phnom Penh Autonomous Port and Sihanoukville Autonomous Port), airports, sewage system, wastewater treatment plant, ferry port, building and land under DPWT authorization. - Managing, as well as maintaining public orders and landscaping of along national roads and the roads within the provincial - municipal locations; - Researching on development plans for transport works at provincial - municipal level.
3. Organization Chart	



Source: DPWT

4. Responsibility on the Department related to Urban Transport	
Office of Land Transportation	- Manage land transport and logistic by planning the developing of public transportation such as bus taxi parking space passenger station and set the run line and other modes of transport in Phnom Penh. - Manage and prepare the license for land transport vehicle and shop that sell all kind of vehicles as well as follow up, control and evaluate the vehicles business activities and car dealership in Phnom Penh. - Manage business registration and provide the license for vehicle garage, repairing and assembling all types of vehicles. - Advertising education Introduce laws, regulations, techniques and other relevant legal documents to transport company owners or vehicle owners and automotive shop in Phnom Penh. - Cooperate with specialized units of the Ministry and relevant authority to facilitate cross-border transportation in Phnom Penh. - Cooperate with relevant authorities in overseeing transportation work and pollution cause by all kinds of vehicles in Phnom Penh. - Cooperate with specialized units of the Ministry to prevent the crime of overweight transport and the wrong processing of vehicles in Phnom Penh. - Collaborate and coordinate with the relevant authorities in order to facilitate the flow of traffic in the geography of Phnom Penh, as well as to educate, guide and disseminate laws and regulations in schools, communities and other public places. - Keep both software and hardware licenses within the department's jurisdiction. - Make a summary report of work activities according to the schedule of his office. - Perform other duties as assigned by the department management.

Office of safety traffic	- Management all traffic safety and planning all traffic safety activities of land transport in Phnom Penh. - Monitor and inspect driving school and disseminate the law on road traffic and traffic safety in those places where there are frequent traffic accidents in Phnom Penh. - Compile and analyze statistics the data of victim and Identify locations with frequent traffic accidents and make corrections Or put traffic signs in those places where frequent accidents in Phnom Penh. - Cooperate with specialize units of the Ministry, institute, and relevant partner to set up the training for driver who drive all type of vehicle about the safety road traffic and to use the road in jurisdiction of the department. - Cooperate with relevant authority to educated, guide and advertise about the safety road traffic in order to maintaine and beauty along the public street in Phnom Penh. -Participate in the driving license examination committee and driving instructors and monitor driving school in Phnom Penh. - Participate with specialize institute under the Ministry in conducting road traffic safety audits and assessing road safety levels. - It is the personal assistance of secretarial of state of safety road traffic committee of Phnom Penh. - Management and put the traffic sign, road name of Phnom Penh. - Make a summary report of work activities according to the schedule of his office. - Perform other duties as assigned by the department management.

Source: Prakas No. 344 BrK.SK.BCh dated 31 August 2001 on Organization and Functioning of Provincial – Municipal Department of Public Works and Transport.

Table 3.2.1 Number of Staff in DPWT

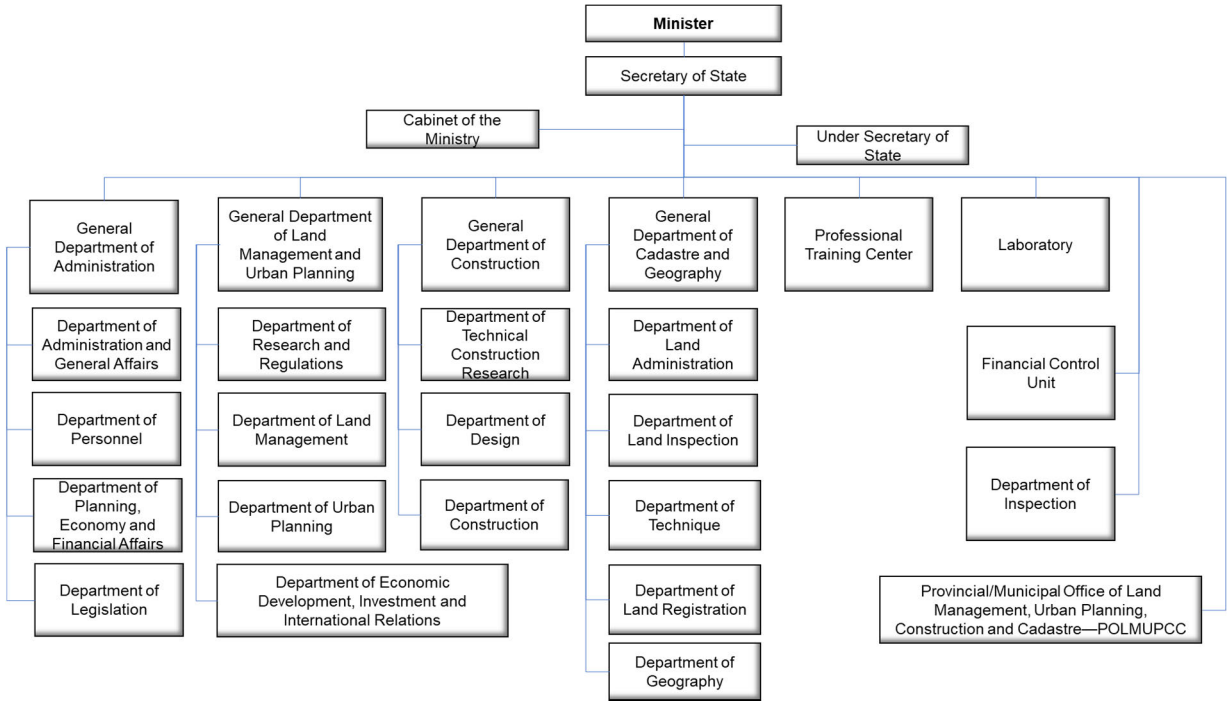
No.	Office/Division	Permanent Staff			Contractual Officers	Grand Total
		Engineer/ Architect	Female	Total		
1	Director Board	5	1	8	-	8
2	Public Affairs Office	2	3	8	5	13
3	Finance and Planning Office	2	4	12	2	14
4	Technical Office	16	1	19	4	23
5	Public Works Office	10	9	28	37	65
6	Land Transport Office	1	7	18	6	24
7	River Transport, Ferry and Port Office	-	-	-	-	-
8	Road Traffic Safety Office	-	-	-	-	-
9	Public Order and Cleansing Division	-	-	6	19	25
10	Dike and Riverbank Protection Division	2	-	3	-	3
11	Drainage Pumping Station and Sewage Treatment Plant Office	6	10	26	171	197
12	Public Lighting and Traffic Signal Office	3	-	6	16	22
13	Public Garden and Plant Office	4	5	16	279	295
14	Vehicle Registration Division	2	25	51	14	65
15	Motorbike Registration Division	2	8	22	14	36
16	Driving Licence Division	8	11	44	3	47
17	District Public Works Offices	10	4	30	-	30
	Total	73	88	297	570	867

Source: DPWT * as of May 31.2019.

3.2.4 MLMUPC

1. Name	Ministry of Land Management, Urban Planning and Construction
2. Responsibility	Governing land use, urban planning, construction projects, and for the resolution of land use conflicts

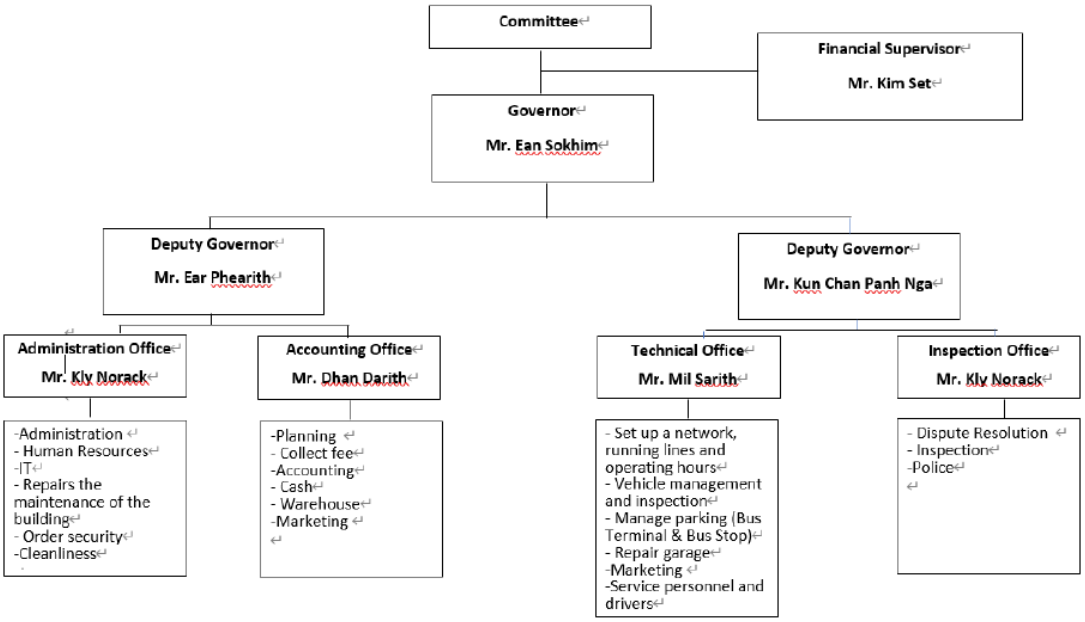
3. Organization Chart



Source: MLMUPC

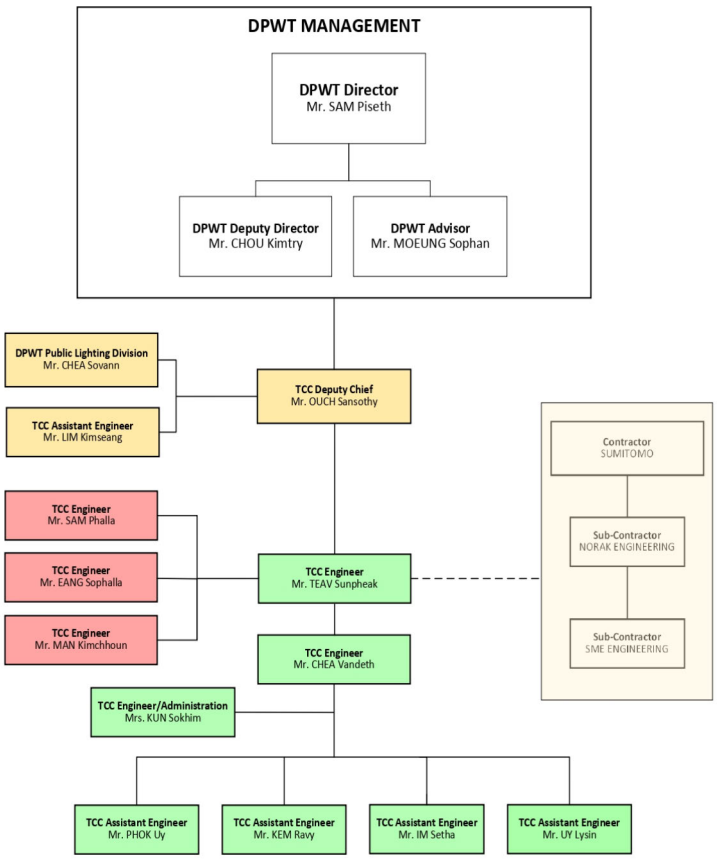
4. Responsibility on the Department related to Urban Transport	
Urban Planning	- Proposing legislation, provisions, and regulations on urban planning; - Implementing urban planning policies to develop cities, suburbs, towns, and other areas affecting the cities in order to improve the social order, beauty, safety, and well-being of the cities; - Studying and designing master plans and specific plans by dividing city and urban areas into commercial centers, handicraft, administrative, educational, and residential areas, reserved areas, schools, sport courts, road shoulders, recreational areas, hospitals, sacred places, religious sites, and public parks, etc. - Cooperating with relevant institutions to set up plans for communications infrastructure, public transportation systems, sewer systems, clean water supplies, electricity, telecommunications, and the other facilities needed in the city; - Reorganizing and improving quality of the city and new developed areas in city; - Organizing plans to create new towns and new community development areas; - Monitoring, documenting, and analysing data on the socio-economy, supply capability, transportation, census, density, demography, and other factors affecting city development; - Examining and issuing construction licenses; - Monitoring and taking measures to implement urban planning policies effectively.

Source: Sub Degree No. 62ANKR.BK dated 20 July 1999 on Organization and Functioning of Ministry of Land Management, Urbanization and Construction.



Source: JST

Figure 3.2.1 Organisation Chart of CBA



Source: TCC

Figure 3.2.2 Organisation Chart of Traffic Control Centre as of April 2021

3.3 Urban Development Project

Table 3.3.1 Updated Status of Housing and Condominiums Development Projects

No	Project Name	Unit	Project Year		Status
			Start	End	
Housing Development Projects					
1	Orkide Villa The Royal	893	2015	2017	Constructed
2	Orkide Villa The Botanic city	770	2017	2018	Under Construction
3	Comko City R2 Secret Garden	134	2015	2020	Under Construction (partially)
4	Phnom Penh Thmey Regent Park	114	2015	2017	Constructed
5	New World Chamkadong I	2,115	2016	2017	Constructed
6	New World Chamkadong II	1,030	2016	2017	Constructed
7	Mongkul Phnom Penh Toul Sangke II	159	2016	2017	Constructed
8	Mongkul Phnom Penh Krol Ko	382	2017	2019	Constructed
9	The Star Platinum Herminus	83	2013	2017	Constructed
10	The Star Platinum Mercurean II	741	2015	2017	Constructed
11	The Star Platinum Polaris I	1,554	2015	2017	Constructed
12	The Star Platinum Polaris II	512	2016	2017	Constructed
13	The Star Platinum Rosato	896	2015	2017	Constructed
14	The Star Platinum Paradigm	112	2016	2018	Constructed
15	The Star Platinum Euro Ville	494	2017	2019	Constructed
16	The Star Imerald	177	2015	2017	Constructed
17	The Star Premier	1,120	2013	2017	Constructed
18	The Star Natural	411	2014	2017	Constructed
19	The Star Jumeirah	635	2015	2017	Constructed
20	Lim Cheang Hak Ou Dim II	533	2015	2017	Constructed
21	Lim Cheang Hak Phsar Che Ko	109	2016	2018	Constructed
22	Lim Cheang Hak Veal Sbov	185	2016	2017	Constructed
23	Lim Chheang Hak Chamkar Dong	733	2014	2017	Under Construction (partially)
24	Lim Chheang Hak Phnom Penh Thmei	128	2016	2017	Constructed
25	Angkor Phnom Penh	332	2013	2017	Constructed
26	Hi-tech Luxery	33	2017	2018	Constructed
27	Villa Town	248	2015	2017	Constructed
28	New Home	201	2016	2017	Constructed
29	The Park Land Sen Sok	793	2014	2017	Constructed
30	Heng Heang City	204	2015	2017	Constructed Partially
31	Moha Sensok	679	2016	2018	Constructed
32	Lay Kong Chea Sopheara	179	2012	2017	Constructed
33	Lay Kong choam Chao	325	2016	2017	Constructed
34	Lay Kong Charmkar doung Phum Morl Sambo	538	2016	2017	Constructed
35	CHEA RY - TOL LON	425	2016	2017	Constructed
36	JASMINE Residence	82	2016	2017	Under Construction
37	Phnom Penh Thmey Chea Sophara	240	2017	2019	Constructed
38	Phnom Penh Sok San	160	2017	2018	Constructed Partially
39	New World Kambol II	715	2017	2019	Constructed
40	New World Chhouk Va I	1,601	2017	2019	Constructed
41	New World Chhouk Va II	2,850	2017	2019	Constructed
42	New World Chhouk Va III	668	2017	2019	Constructed
43	New World Kampong Kou Srov I	1,812	2017	2020	No (Vacant Lot)
44	New World Kampong Kou Srov II	234	2017	2018	No (Vacant Lot)

No	Project Name	Unit	Project Year		Status
			Start	End	
45	The Park Land TK	52	2018	2019	Under Construction
46	The Park Land 598	269	2017	2019	Constructed
47	Long Ny	200	2017	2019	Constructed
48	Arata Garden Residences	481	2018	2020	Constructed
49	Hong Lay	617	2017	2020	Constructed
50	New Hope City	1,406	2017	2020	Under Construction
51	Lim Chheanghak	122	2017	2018	Constructed
52	Thai Chhounkry	163	2017	2019	Constructed
53	SJS 1	234	2017	2018	Constructed
54	The Mekong Royal	1,031	2015	2017	Constructed
Condominium Development Projects					
1	D.I Rivera	1,232	2013	2018	Constructed
2	Camko City R1, Condo	160	2007	2017	Under Construction
3	X.O Condo	143	2014	2018	Under Construction
4	Diamond One (Diamond Condo)	402	2014	2017	Constructed
5	Sky Villa Condominium	269	2016	2018	Constructed
6	Axis Residences	566	2015	2018	Constructed
7	TK Royal One	183	2015	2017	Constructed
8	Monorom Residence	105	2015	2017	Constructed
9	Bodaiju Residences	928	2015	2021	Constructed
10	La Vie Residence	180	2015	2018	Constructed
11	Sky 31 Condominium	230	2015	2018	Constructed
12	PS Crystal Condominium	120	2015	2018	Constructed
13	East View Residence	1,189	2015	2018	Constructed
14	Highland Condominium	229	2015	2017	Constructed
15	North Park Condominium	185	2015	2018	Under Construction
16	Prince Central Plaza	1,768	2015	2018	Constructed
17	Orkide The Royal Condominium	1,586	2016	2019	Under Construction
18	Toul Sangke Green View Tower	178	2016	2018	Constructed
19	Diamond Twin Tower	482	2015	2018	Constructed
20	The Penthouse Residence	458	2016	2018	Constructed
21	The Peak Phnom Penh	1,014	2016	2020	Constructed
22	The 352 Platinum I	130	2015	2017	Constructed
23	The Gateway Cambodia	566	2016	2019	Under Construction
24	Sino Plaza	1,036	2015	2018	Under Construction
25	The Garden Residency	189	2015	2018	Constructed
26	One Park	1,598	2015	2018	Constructed
27	The Skyline	792	2016	2018	Constructed
28	BO AO CITY	1,980	2016	2020	No (Vacant Lot)
29	Royal Condo	224	2016	2018	Constructed
30	The Star Puo Laris 23 Condo	1,068	2016	2019	Constructed
31	The Sky Tree Condominium	1,104	2016	2019	Constructed
32	MEKONG VIEW TOWER V	400	2017	2018	Constructed
33	MEKONG VIEW TOWER VI	262	2016	2018	Constructed
34	Residence L Boeng Trabek II	209	2016	2018	Constructed
35	88 Suites	88	2016	2018	Under Construction
36	Star City Cambodia	455	2016	2018	Constructed
37	Kingtown One Park	356	2017	2019	Under Construction

No	Project Name	Unit	Project Year		Status
			Start	End	
38	Bali Scenery Resort No.6	616	2017	2019	No (Vacant Lot)
39	Diamond One II	300	2018	2020	Constructed
40	Urban Lofts	182	2017	2020	Constructed
41	Prince Modern Plaza	700	2017	2019	Constructed
42	Parkway Square Condominium	1,500	2016	2020	Constructed
43	Residence L Boeng Tompun	532	2017	2020	Constructed
44	CEO TK Pacific	972	2017	2020	Under Construction
45	Bali Scenery Apartment No.5	378	2016	2019	Constructed
46	Olympia City	2,345	2012	2022	Constructed
47	The Brudge	2,241	2014	2018	Constructed

Source: JST based on the data by "Preparatory Survey for Phnom Penh Urban Railway Development Project in the Kingdom of Cambodia, 2020 (JICA)"