THE KINGDOM OF CAMBODIA
PHNOM PENH CAPITAL CITY
MINISTRY OF PUBLIC WORKS AND TRANSPORT

THE PROJECT FOR COMPREHENSIVE URBAN TRANSPORT PLAN IN PHNOM PENH CAPITAL CITY (PPUTMP)

FINAL REPORT
MAIN TEXT

December 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

METS RESEARCH & PLANNING, INC.
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN, INC.
ORIENTAL CONSULTANTS CO., LTD.
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ABBREVIATIONS and ACRONYMS

AC	Advisory Committee
ADB	Asian Development Bank
AGTS	Automated Guideway Transit System
ASEAN	Association of South-East Asian Nations
ATC	Area Traffic Control
BAU	Bureau of Urban Affairs
BRT	Bus Rapid Transit
CBD	Central Business District
CCTV	Closed Circuit Television
CINTRI	Canadian and Cambodian Joint-Venture
CO	Carbon Monoxide
CO2	Carbon Dioxide
CP	Counterpart
DCC	Department of Climate Change
DLMUPCC	Department of Land Management, Urban Planning, Construction and Cadastral
DLT	Department Land Traffic
DOE	Department of Environment
DOEPP	Department of Environment, Phnom Penh Capital City
DPS	Development Corporation Partners
DPWT	Department of Public Works and Transport
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EXIM	Export Import
F/S	Feasibility Study
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GNP	Gross National Product
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
HIS	Home Interview Survey
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
ICD	Inland Container Depot
IMF	International Monetary Fund
IP	Internet Protocol
IPCC	Intergovernmental Panel on Climate Change
IRR	Inner Ring Road
JICA	Japan International Cooperation Agency
JICA 2001MP	Urban Transport Master Plan in 2001

LRT	Light Rail Transit
MEF	Ministry of Economics and Finance
MLMUPC	Ministry of Land Management, Urban Planning and Construction
MOE	Ministry of Environment
MOP	Ministry of Planning
MPWT	Ministry of Public Works and Transport
MRD	Ministry of Rural Development
NGO	Non-Government Organization
NiDA	National Information Communications Technology Development Authority
NO2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NPV	Net Present Value
NRSC	National Road Safety Committee
NSDP	National Strategic Development Plan
OD	Origin-Destination
ORR	Outer Ring Road
PCD	Pollution Control Department
PCU	Passenger Car Unit
PDR	People's Democratic Republic
PIDP	Phnom Penh International Dry Port
PM	Particulate Matter
PMU	Project Management Unit
PPAP	Phnom Penh Autonomous Port
PPCC	Phnom Penh Capital City
PPCH	Phnom Penh City Hall
PPHPD	Passengers Per Hour Per Direction
PPP	Public-Private Partnership
PPSEZ	Phnom Penh Special Economic Zone
PPUTMP	Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City
PPWSA	Phnom Penh Water Supply Authority
PT	Person Trip
PT-1	Public Transport Project No.1
PTMU	Public Transport Management Unit
PUTA	Phnom Penh Urban Transport Authority
RGC	Royal Government of Cambodia
ROW	Right of Way
RR-II	Middle Ring Road
RR-III	Outer Ring Road
RR-IV	Outer-outer Ring Road
SC	Steering Committee
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SO2	Sulphur Dioxide

TAZs	Traffic Analysis Zones
TC	Technical Committee
TDM	Traffic Demand Management
TEU	Twenty-foot Equivalent Unit
THC	Total Hydrocarbon Compound
TOD	Transit-Oriented Development
TRR	Toll Royal Railway
VAT	Value Added Tax
VMS	Variable Message Sign
2020MP	Phnom Penh Urban Planning Master Plan 2020

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1. INTRODUCTION

1.1 Project Background

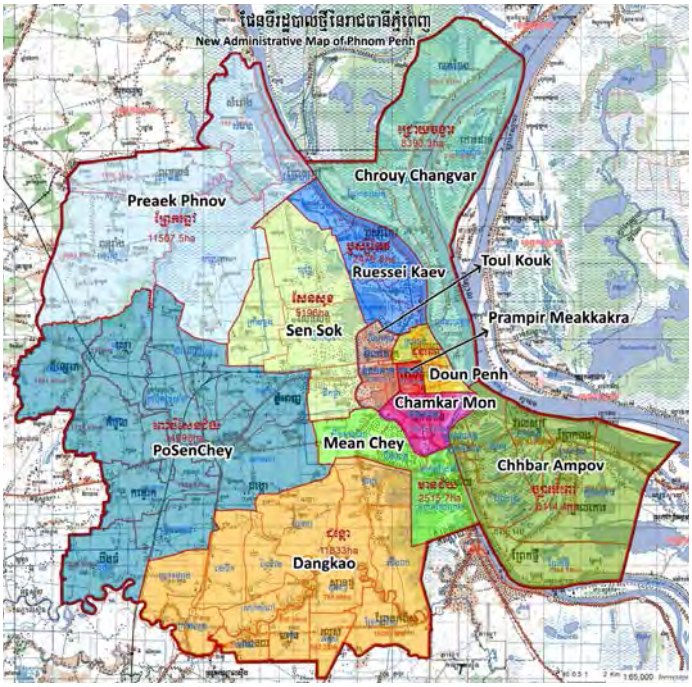
Phnom Penh, the capital city of Cambodia, has a population of about 1.85 million (as of 2012) and a land area of 678 km^2. In recent years, traffic conditions and traffic accidents in the capital city have been worsening due to the rapid increase of vehicles mainly spurred by the country's vital economic growth. The Japan International Cooperation Agency (JICA) conducted "The Urban Transport Master Plan in the Phnom Penh Metropolitan Area" (JICA 2001MP) with the target year of 2015 based on 1) road development in the urban area; 2) introduction of bus system; 3) traffic management schemes including intersection improvement and readjustment of traffic signal phasing; 4) traffic safety and enforcement; and 5) capacity development. Through "The Project for Traffic Improvement in Phnom Penh City" (March 2007-2010), JICA has promoted the transfer of technologies for intersection improvement, installation of traffic signals in the city, and traffic safety to counterparts of Phnom Penh.
Road construction was completed earlier than planned in the JICA 2001MP in Phnom Penh, especially in the suburban area.
However, traffic congestions and traffic accidents have increased due to the rapid increase of vehicular traffic and the lack of public transport, which did not materialize even though it was proposed by JICA 2001MP. A request was therefore made by the Cambodian Government for the conduct of the project to revise the JICA 2001MP and to develop a comprehensive urban transport plan including the action plans for solving transport problems.
It is noted that the changes of transport conditions in Phnom Penh from 2001 to 2012 are obvious, namely: 1) population stagnation in the central area and rapid increase in suburban areas (population growth of central 3 Khans decreases by 3%, suburban 5 Khans increases by 69%); 2) deterioration of traffic conditions; 3) expansion of City's jurisdiction from 376 km^2 to 678 km^2 in 2010; and 4) progress of large-scale development by the private sector.
Based on the background above, JICA dispatched the detailed design study team for the "Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City (PPUTMP)" in October 2011 to conduct discussions concerning the formulation of the urban transport master plan in Phnom Penh and related technology transfer. Then, the Record of Discussion (R/D) containing the agreed items was signed.

1.2 Project Objectives

The objectives of the Project were to formulate a comprehensive urban transport plan for Phnom Penh Capital City (PPCC), of which the target year is 2035, and to conduct a pre-feasibility study (pre-F/S) on a priority project.
In addition, recommendations for promoting were made for strengthening and improving the implementation capacity of the urban transport-related agencies. In this way, there would be reassurance of the effectivity of the study results and the realization of the proposed urban transport plans in PPCC.

1.3 Project Area

The Project covered the whole administrative area of PPCC, which encompasses 678 km^2 (refer to Figure 1.3-1).



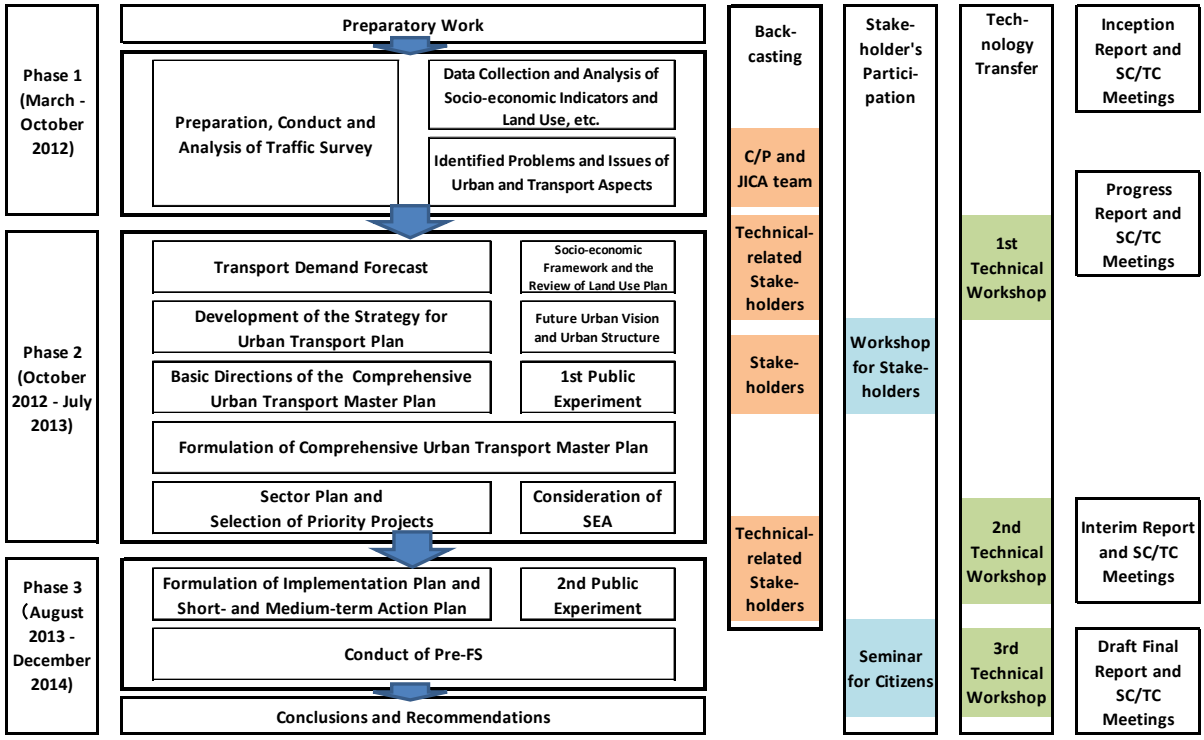
Name of Khan		1998	2008	2012
01	Chamkar Mon	187,082	182,004	184,200
02	DounPenh	131,913	126,550	119,500
03	Prampir Meakkakra	96,192	91,895	93,300
04	TuolKouk	154,968	171,200	186,100
01-04 Sub-total		**570,155**	**571,649**	**583,100**
05	Dangkao	48,921	73,287	96,100
06	PoSenChey	73,414	159,455	234,900
07	Mean Chey	97,190	194,636	282,700
08	Chhbar Ampov	108,796	133,165	160,500
09	Ruessei Kaev	76,473	115,740	152,600
10	Chrouy Changvar	53,231	68,708	84,000
11	Sen Sok	70,676	137,772	198,600
12	Preaek Phnov	34,574	47,313	59,700
05-12 Sub-total		**563,275**	**930,076**	**1,269,100**
Total	**Population**	**1,133,430**	**1,501,725**	**1,852,200**
	Area (KM2)		**678**	

Source: Phnom Penh Capital Hall and PPUTMP Project Team

Figure 1.3-1 Project Area

1.4 Project Framework

The overall framework and composition of the Project is shown in Figure 1.4-1. It is basically divided into three phases based on submission of the Progress Report and Interim Report. Wherever applicable in the urban transport master planning, back-casting, stakeholder's participation were utilized. Technology transfer to counterparts was effected during the project.



Source: PPUTMP Project Team

Figure 1.4-1 Framework of the Project

(1) Phase 1: Data collection/traffic surveys and analysis

This phase aims to diagnose the existing urban and transport situation in PPCC based on the various existing data and results of the transport/traffic surveys conducted in the project.

(2) Phase 2: Framework, traffic demand forecast and master plan formulation

This is the most important phase of the project. Based on the socio-economic frame and review of the 2020MP and transport demand forecast, the strategy of urban transport master plan was formulated by back-casting approach with stakeholder participation. At the same time, a draft of short- and medium-term plans was presented. For verification of these draft plans, the first public experiment was conducted. Then, the formulation of the comprehensive urban transport master plan which is the 2035 urban transport structure in Phnom Penh was completed. Sectoral plans (public transport, road and traffic management, etc.) and priority projects were selected and a strategic environmental assessment was completed.

(3) Phase 3: Formulation of the implementation/action plans and conduct of pre-F/S

In this phase, the implementation plan, short- and medium-term action plans and pre-F/S for priority projects were completed. The second public experiment for bus operation was also conducted. A stakeholder workshop and seminar were held at the stage of developing the basic considerations of the comprehensive urban transport master plan and the last stage of the project, respectively. At the stage of public experiments, stakeholders were invited to participate in activities so that they have an understanding of the importance of the transport measures to urban life.

(4) Back-casting

Together with the conventional methodology of formulating an urban transport master plan, a back-casting approach, allowing the urban transport planning concept to be shared among stakeholders, was utilized by this project.

(5) Creation of opportunity of stakeholder's participation

Creating an opportunity for stakeholder participation, which is important for the formulation of urban transport master plan by back-casting, was provided.

(6) Technology transfer

Technology transfer was affected throughout the project period with on-the-job training. Four times of technical workshop to improve planning skills was conducted. Personnel from engineering-related agencies attended and participated in the workshop.

1.5 Reports

The final reports of this project are as follows.

a) Executive Summary (English Version)
b) Executive Summary (Japanese Version)
c) Main Text (English Version)
d) Appendix (English Version)

2 URBAN AND URBAN TRANSPORT PROBLEMS/ISSUES

Based on the data collection, transport surveys including the Home Interview Survey (HIS) and interview conducted with urban transport-related agencies, the urban and transport problems/issues are summarized below.

2.1 Road Traffic Situation

It has been observed that road traffic conditions in Phnom Penh Capital City (PPCC) is worsening with traffic congestions and reduced travel speeds as inevitable outcomes of not only the population concentration and rapid increase of vehicle registrations but also limited road space especially in the dense city center.

2.1.1 Road Traffic Volume and Its Changes (Comparison between Year 2000 and Year 2012)

(1) Road Traffic Volume along Major Roads

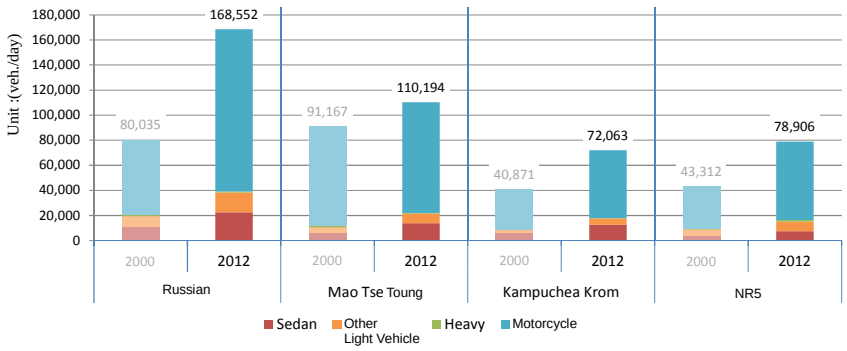
The traffic volume along major roads is exhibiting the following characteristics:

- High traffic volume is seen on roads near the Inner Ring Road (IRR) and the highest traffic volume (about 170,000 vehicles/day) is observed along Russian Blvd.
- On the other hand, traffic volume in the city center is about 60,000 - 90,000 vehicles/day.
- Motorcycles comprise 75% of the vehicular traffic.

(2) Changes in Traffic Volume along Major Roads

The growth rate of road traffic volume over a period of 12 years (2000 - 2012) is 1.2 to 2.1 times. Details are given below.

- The growth rate of radial roads such as Russian Blvd., Kampuchea Krom and NR5 is higher than that of ring roads.
  - ➢ Expansion of urbanization to northern and western suburban areas.
  - ➢ Improvement of IRR which serves as a diversion road for other ring roads.
- Motorcycles are observed at all survey points registering the highest percentage share (approximately 80%) among all vehicle types.
- There is a large decrease in vehicular traffic in most of the survey points, except for NR5.
  - ➢ Many factories have transferred to the suburban area and the development of commodity facilities (dry ports) has accelerated in suburban areas as well.



Source: PPUTMP Project Team

Figure 2.1-1 Change of Traffic Volume

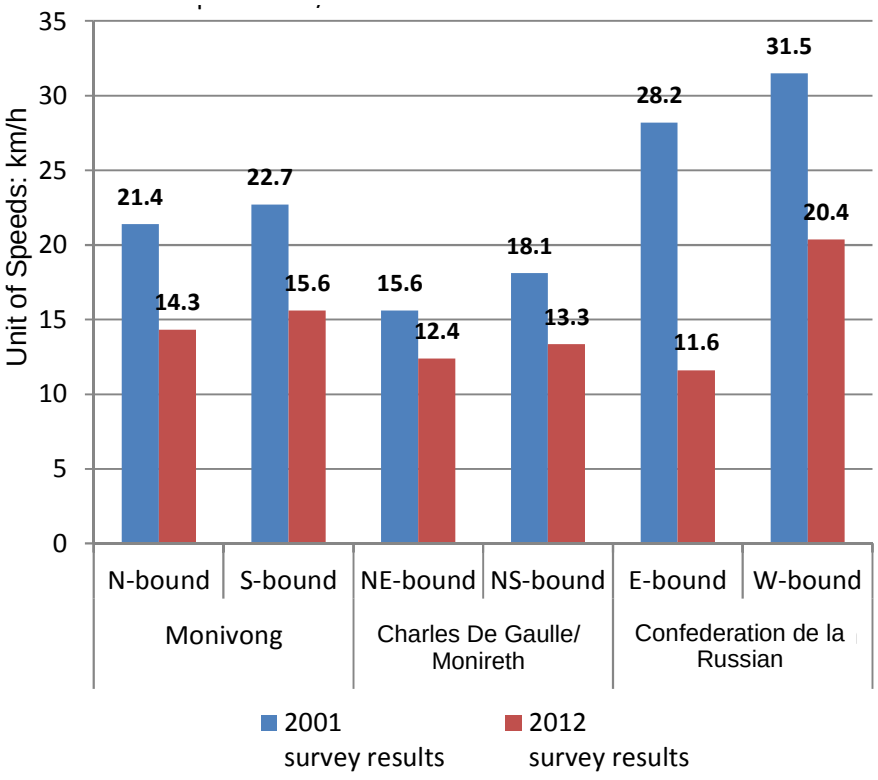
(3) Change of Travel Speed

Travel speed along all corridors in the 2012 survey results is lower than that of the Urban Transport Master Plan (JICA 2001MP).
On most of the corridors, travel speed is lower than 20 km/hour.

Table 2.1-1 Change in Travel Speed Unit: (km/hour)

Street Name	Direction	2001 survey results	2012 survey results
Monivong	N-bound	21.4	14.3
	S-bound	22.7	15.6
Charles De Gaulle/ Monireth	NE-bound	15.6	12.4
	NS-bound	18.1	13.3
Russian	E-bound	28.2	11.6
	W-bound	31.5	20.4

Source: PPUTMP Project Team



Source: PPUTMP Project Team

Figure 2.1-2 Change in Average Travel Speed

2.1.2 Identified Problems/Issues

- Along major roads in the city center is a deterioration of traffic conditions due to the increase of traffic demand and limited space for road development.

2.2 Road Development

Road development can be difficult for a number of reasons depending on location; in the case of city center, it is the limited road space, and for suburban areas, the low road density and many missing links.

2.2.1 Road Network in PPCC

(1) Road Network Pattern

The city's basic road network pattern is a radial-ring pattern. Radial roads in the city center are Monivong, Norodom, Russian and Charles De Gaulle/Monireth, and these roads connect NR1, NR2, NR3, NR4, NR5 and NR6 in the suburban area. On the other hand, ring roads are Sihanouk, Mao Tse Toung, IRR and Outer Ring Road (ORR) from city center to suburban area.

(2) Urban Area inside IRR

Figure 2.2-1 shows the rehabilitation and improvement projects inside IRR, which had been either under construction or proposed in the JICA 2001MP. All the rehabilitation/improvement works on these roads have been completed by now by using local funds. In addition, most of the unpaved local district streets have already been paved as well. It is also noted that the second Monivong Bridge and two flyovers at Kbal Thnal and Pet Lork Sang have been completed. Only the missing links proposed in the JICA 2001MP have not been completed yet because of relocation problems of affected houses.

Source: Department of Public Works and Transport (DPWT)

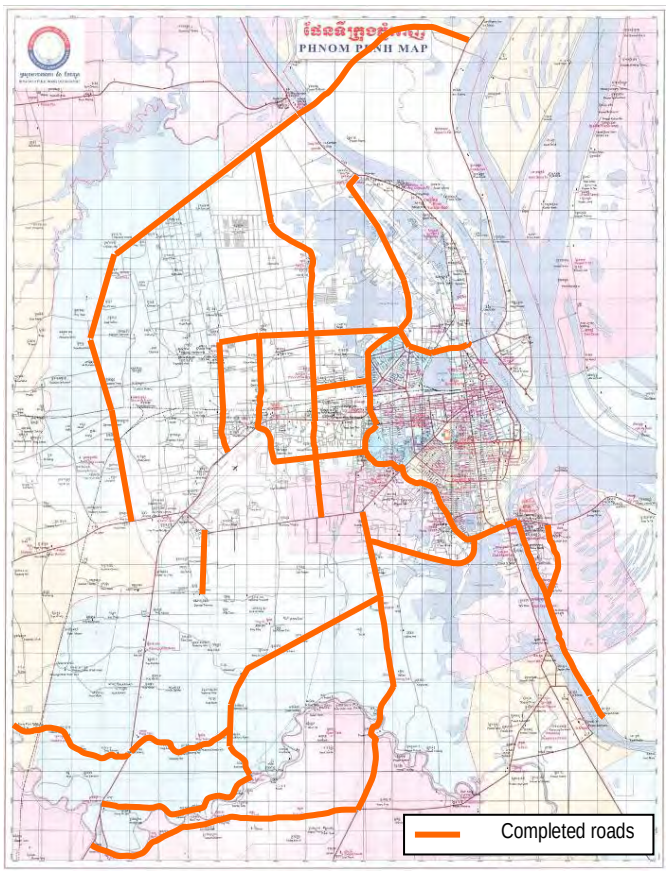
Figure2.2-1 Progress of the Proposed Roads in Urban Area

In addition to the rehabilitation/improvement projects proposed in the JICA 2001MP, some roads have been widened by using local funds. They are as follows:

- IRR: The whole stretch of IRR was widened from 2 lanes to 4 lanes.
- Russian: About 300 m section from Monivong was widened at the time of the urban renewal project including the intersection improvement of Russian/Monivong.
- Tep Phorn: About 100 m from Neang Kong Hing Intersection was widened at the time of the urban renewal project.

(3) Suburban Area

Compared with the road network improvements in the urban area, which have been prioritized, the road projects in the suburban area proposed in the JICA 2001MP have seen less progress. The completed projects are shown in Figure 2.2-2.



Source: DPWT

Figure 2.2-2 Progress of Road Projects in Suburban Area

Among others, the prominent road projects implemented are as follows:

a) Kob Srov Dike Road (a part of ORR) connecting from NR4 to NR6 including Preaek Phnov Bridge
b) Ruessei Kaev Bypass (Link between IRR and NR5)
c) Hanoi Road connecting Chaom Chau Road and Kob Srov Road
d) Cheung Aek Bypass connecting Chaom Chau Road and NR2
e) Airport Access Road (Ou Baek Kaam Road, a part of Kouk Chambak Road)

2.2.2 Road Characteristics

(1) Percentage of Paved Roads

The percentage of paved roads in the city center (inner four Khans) is 94%; in contrast, only 27% of roads in the suburban area are paved.

(2) Road Density

Road density is defined as the road length per administration area. It is usually employed as an indicator for examining the degree of the road network development in the urban area.
Table 2.2-1 shows the road density of Phnom Penh in comparison with other cities in Asia.

Table 2.2-1 Road Density Comparison

Cities	Area (km2)	Population (million)	Ave.Pop Density (person/km2)	Road Length (km)	Road Density (km/km2)	Public transport share (%)	Remarks		
							population (year)	Road (year)	public transp. (year)
Phnom Penh	678	1.5	2,212	1,379	2.03	15	2008	2011	2001
Kuala Lumpur	243	1.6	6,667	1,213	4.99	20	2005	2005	2005
Singapore	693	4.6	6,637	3,234	4.67	63	2005	2005	n.a.
Hong Kong	1,108	7	6,318	2,009	1.81	90	2005	2005	n.a.
Bangkok	1,569	5.7	3,633	4,076	2.60	50	2000	2000	2000
Vientiane	3,920	0.79	202	2,004	0.51	-	2010	2004	2004
Ho Chi Minh	2,095	7.2	3,437	3,670	1.75	-	2009	2009	n.a.
Hiroshima	905	1.2	1,326	4,323	4.78	20	2011	2011	2008
Tokyo	2,187	8.9	4,070	24,342	11.13	66	2010	2010	2009

Note: the public transport share is excluding walk trips.
Source: IMF Economic Outlook Database,ADB Economic Outlook 2010, Current Situation and Development planning for Transportation of Ho Chi Minh City towards 2020, IGI Global :Sustainable Urban infrastructural development in Southeast Asia 2010.

The average road density of Phnom Penh is approximately 2.0 km/km^2, which is higher than that of Vientiane or Ho Chi Minh. However, the administration areas of those cities are quite large, forming a metropolitan area that probably involves their surrounding rural areas. Hong Kong also has a lower road density while the high share of public transport may be offsetting the insufficiency in the road network.
When compared to cities of similar sizes like Kuala Lumpur, Singapore or Hiroshima, Phnom Penh's road density seems to be a little low.

Table 2.2-2 shows the road density by district. It can be said that the average road density in the central districts is already sufficiently high, 12.2 km/km^2 in average, which is compatible to the Central Business District (CBD) area of Hiroshima City. On the other hand, those for the other four Khans outside IRR are still at a low level, only 1.6 km/km^2. It indicates that the road network in the suburban area is still insufficient.

Table 2.2-2 Road Density by District

	Name of District	Area (km2)	Population (2008)	Pop Density person/km2	Road Length (km)	Road Density (km/km2)	Road Density (km/km2)
1	Chamkar Morn	10.4	182,000	17,500	122	11.7	12.2
2	Daun Penh	7.2	126,000	17,500	51	7.1	
3	7 Makara	2	92,000	46,000	25	12.5	
4	Toul Kork	7.8	171,000	21,923	136	17.4	
5	Dangkao	340.2	258,000	758	522	1.5	1.6
6	Mean Chhey	111.1	328,000	2,952	165	1.5	
7	Russey Keo	107.7	196,000	1,820	216	2.0	
8	Sen Sok	92.1	148,000	1,607	143	1.6	
	Total	678.5	1,501,000	2,212	1,380	2.0	
	Hiroshima CBD	15	130,000	8,667	223	14.9	yr :2009
	Tokyo City Area	622	8,900,000	14,309	11,841	19.0	yr :2010

Source: DPWT, Annual Statistics of Hiroshima and Tokyo

(3) Identified Problems/Issues

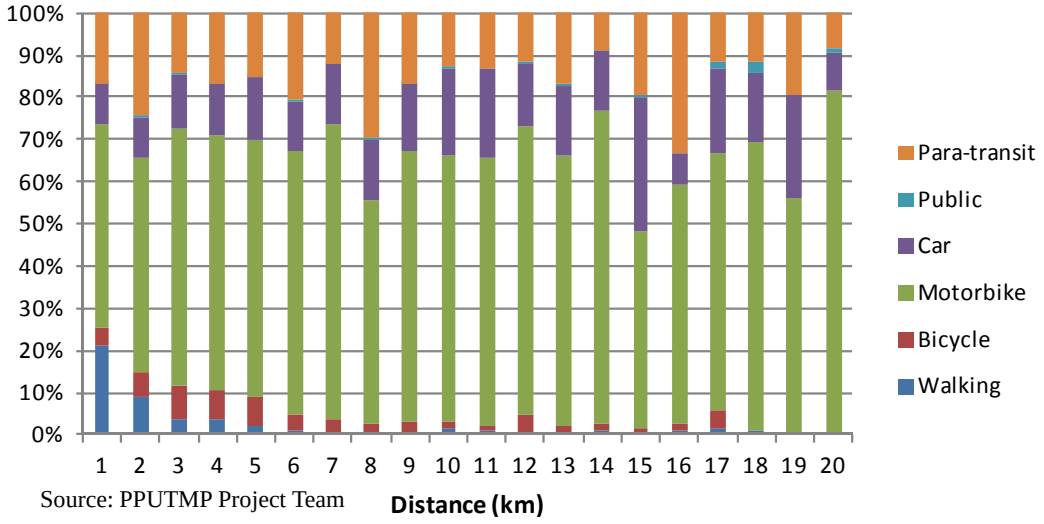
The following problems/issues are identified:

a) There are some discontinuous main roads due to socio-geographical restraints such as rivers or built-up areas (for instance, poor alignment of IRR at Stueng Mean Chey, discontinuousness of St.360 as well as St.608, or no connection between St.430 and St.253, no extension of St.253 and St.261 northward from Russian.).
b) The road density in the suburban area is low and most of the existing secondary roads are not paved, so it is difficult to travel on these roads especially during the rainy season. Their widths are also too narrow to allow vehicles to pass each other safely.
c) Several missing links can be observed in the suburban area such as ORR.
d) There are several important roads of which alignments are not well designed like a zigzag or L-shaped road. The alignment should be improved or another alternative road should be developed before the surrounding area is fully urbanized (for instance, the collector roads such as Krang Thnong Road and Kouk Roka Road located in the northwest suburban area between Hanoi Road and ORR, the collector roads such as Toul Sambo Road and Prey Veaeng Road in the southwest area between Cheung Aek Bypass and ORR).
e) Many residential development projects are ongoing in the suburban area. Although the access roads to the main roads are usually planned to be developed, those may have a possibility to create new bottlenecks since the traffic dispersal from the newly developed area is not properly considered.

2.3 Mobility and Transportation Poor

Based on the examination of the PT Survey result, the following problems and issues can be pointed out about the present transport situation in Phnom Penh.

Following the public experiment of the city bus in 2014 by JICA, PPCH and DPWT have taken over the management of city buses with 3 routes currently being operated. However, people have to use their individual means of transport such as cars and motorbikes even though it might not be adequate. As shown in Figure 2.3-1, travel distance of the motorcycle drivers stretches over 20 km, which might exceed allowable limits of this kind of transport in terms of safety and comfort.



Source: PPUTMP Project Team

Figure 2.3-1 Modal Share by Trip Distance

- According to the PT Survey result, an obvious discrepancy can be seen in average trip number by personal attribute of trip makers. For example, females make fewer trips than males and aged persons have less trip making than the young. These differences might be mostly explained by natural behavioral differences; however, it is pointed out that there are a considerable number of people who cannot make trips due to non-availability of public transport, so called transportation poor.
- Introduction of public transport can provide an affordable means of transport to those who need to make a trip but have no vehicle of their own or have no driver's license even if they own a vehicle. This potential transport demand should be explored.

Table 2.3-1 Difference in Trip Production Rate by Personal Attribute

1. Gender

Gender	Population ('000)	Trip Maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
Male	786.6	85.7	2,210.3	2.8	3.3	8.1
Female	925.5	80.3	2,084.5	2.3	2.8	10.4
Total	***1,712.1***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

2. Age grope

Age Group	Population ('000)	Trip Maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
5-9	126.1	79.5	261.3	2.1	2.6	22.5
10-14	125.2	96.9	334.2	2.7	2.8	36.7
15-19	185.2	93.1	523.1	2.8	3.0	18.2
20-24	208.0	87.7	547.8	2.6	3.0	5.1
25-29	201.8	86.0	517.9	2.6	3.0	4.3
30-34	184.2	86.6	498.3	2.7	3.1	3.2
35-39	119.1	87.3	324.6	2.7	3.1	3.1
40-44	129.5	87.3	371.0	2.9	3.3	2.7
45-49	122.6	85.4	343.4	2.8	3.3	2.5
50-54	98.4	81.5	255.6	2.6	3.2	3.2
55-59	71.9	70.7	159.2	2.2	3.1	4.9
60-64	58.1	54.1	92.7	1.6	3.0	4.7
65-69	37.2	38.8	41.1	1.1	2.9	6.2
70-74	21.9	26.0	15.5	0.7	2.7	4.9
75-	23.1	15.7	9.0	0.4	2.5	11.0
Total	***1,712.1***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

3. Vehicle ownership

Vehicle ownership	Population ('000)	Trip Maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
No Owning	124.9	79.4	289.5	2.3	2.9	17.6
1M/B owning	563.0	81.6	1,333.8	2.4	2.9	13.9
2M/B owning	697.6	84.2	1,732.2	2.5	2.9	6.9
Car owning	326.6	83.1	939.3	2.9	3.5	4.4
Total	***1,712***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

Note: Population indicates the number of people aged over 5 years.
Source: PPUTMP Project Team

2.4 Existing Public Transport System

2.4.1 Para-transit Services

Even with the city bus system operating in 3 routes in PPCC, and except for the availability of para-transit such as Motodop and Motorumok Modern (tuk-tuk), there is no convenient and comfortable public transport mode in the city.

According to the public transport users interview survey, when respondents were asked why they chose “motodop”, most of them pointed at “cheap fare” and “convenience” as reasons rather than “comfortable” or “good accessibility”. Some 8% of users even answered that they chose the motodop because it is the only available mode they can use.
This fact clearly tells that the motodop is selected not for good but rather for negative reasons, pointing to the fact that there is no other option for potential public transport users.

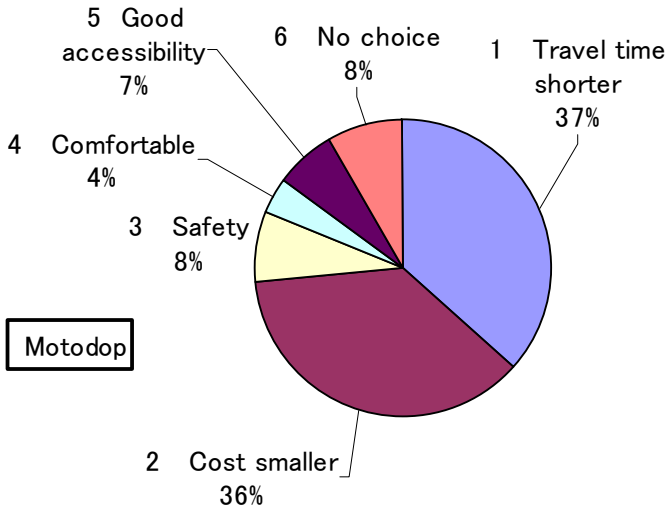
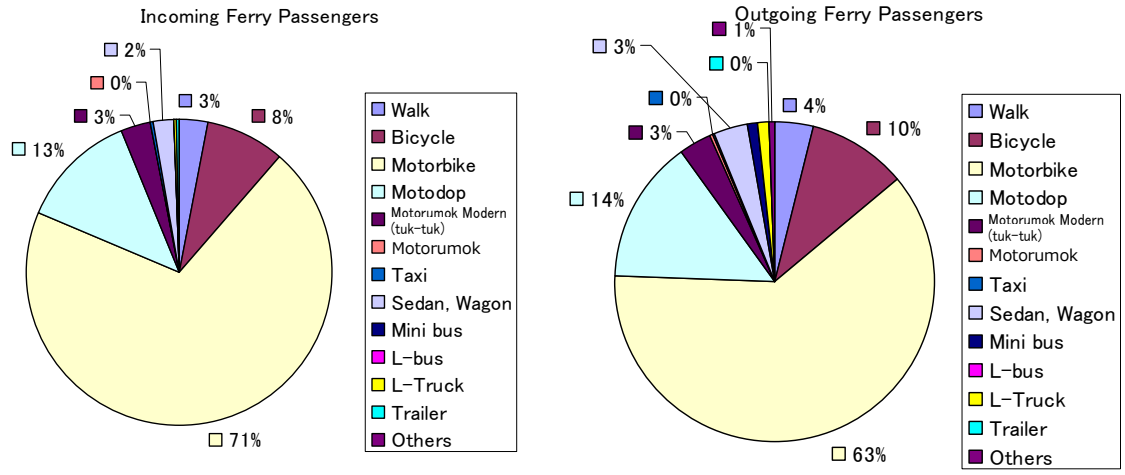


Figure 2.4-1 Reasons for Choosing the Motodop

2.4.2 Feeder Transport for Long Distance Transport Services

Excluding rail services, there are three types of long distance passenger transport services available in Phnom Penh at present. Long distance buses are operated at certain bus terminals located in downtown area; however, it more or less results in traffic congestion and spatial problems of bus depots among other issues. It may be worth considering transferring the bus terminals to the suburban area, connecting with gateway points of the national road network in the future. Eventually, a public transport system should be arranged for intra-urban transport services connecting between suburban bus terminals and downtown area of Phnom Penh, because of a multi-modal transport principle aiming at assuring good connectivity of transport systems.

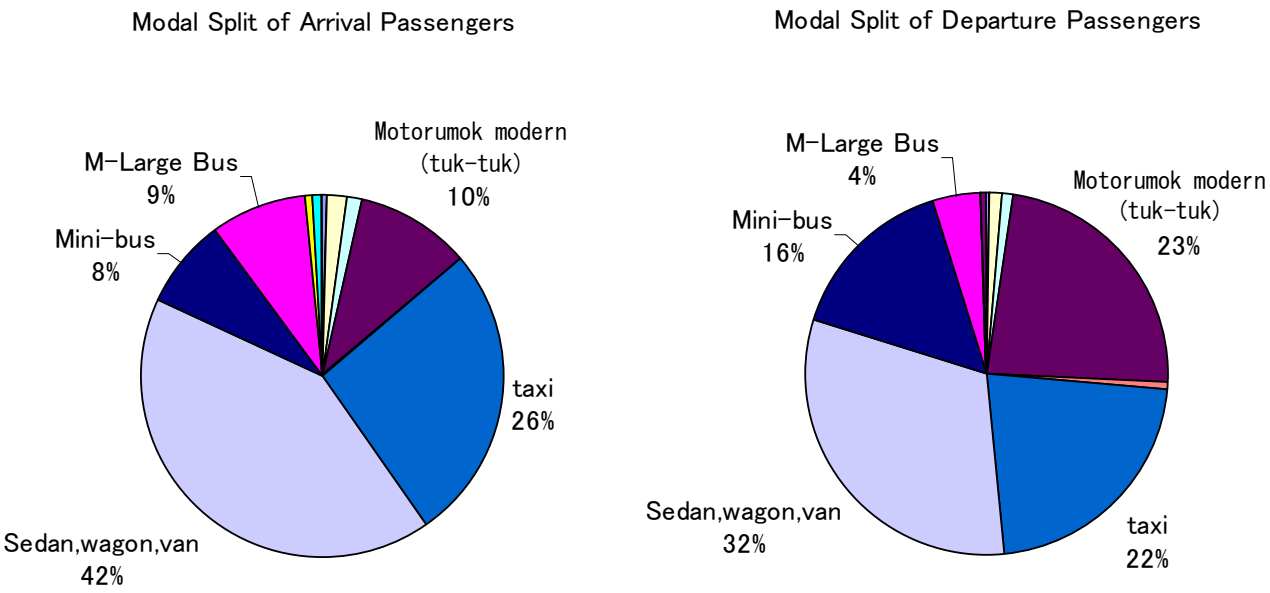
As for water transport, there are a considerable number of ferry transport services connecting Phnom Penh with other provinces, with ferry vessels departing/arriving at the ferry jetty located at Tonle Sap River. Access transport to the ferry jetty is performed mostly by private transport. As shown in Figure 2.4-2, current access transport mode is shared by motorbikes (about 70%), and around 17% of travelers are using para-transit. To make ferry transport services more efficient and convenient, it is important to provide passengers with smooth and reliable transfer services. In this regard, the public transport network should be connected with ferry transport jetties.



Source: PPUTMP Project Team

Figure 2.4-2 Modal Split of Ferry Passengers

As for the air transport, Phnom Penh International Airport is to continue to play its role as main gateway to Cambodia for the time being, although there is a plan to build a new airport in Kampong Chhunang in a long term horizon. Since air travelers require access transport to their final destination in downtown area, the performance of transport access/egress to airport is a crucial matter for airport passengers. In particular, airport passengers, both domestic and foreign, might not have their own transport means individually; accordingly they have to rely on third party transport services. At present airport transport access to Phnom Penh International Airport is performed by relatively small capacity vehicles such as sedans, taxis or para-transit as shown in Figure 2.4-3. However, it is desirable to prepare a public transport system with a large capacity in order to cope with abrupt peaks of transport demand/group tour passengers.

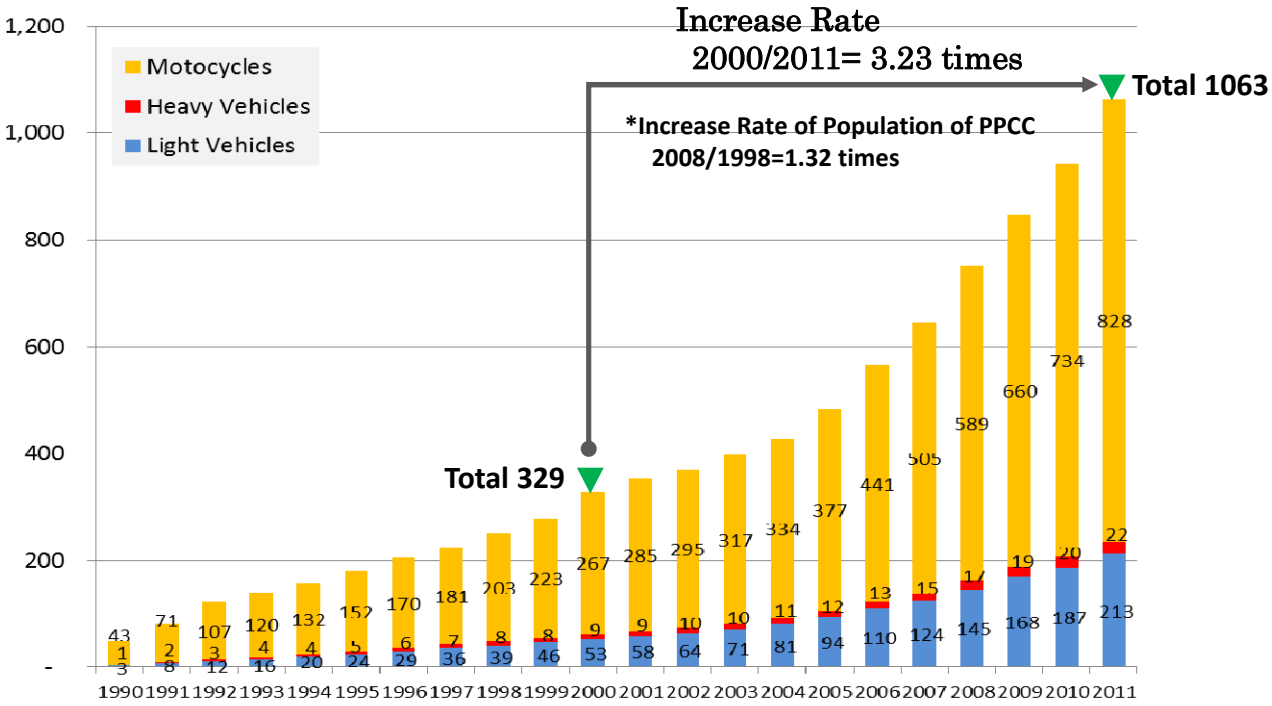


Source: PPUTMP Project Team

Figure 2.4-3 Access of Transportation to Phnom Penh International Airport

2.5 Rapid Motorization

The number of registered light and heavy vehicles in PPCC has rapidly increased, from 4 thousand in 1990 to 268 thousand in 2012 as shown in Figure 2.5.1 below. During the same period, the number of motorcycles increased from 44 thousand to 951 thousand. The number of registered vehicles including motorcycles from 2001 to 2012 increased 3.46 times. However, these numbers are an accumulation from 1990 and do not take into account the scrapped cars.



Source: Phnom Penh City Hall (PPCH)

Figure 2.5-1 Number of Registered Vehicles (unit: '000)

2.6 Traffic Management Measures

2.6.1 Problematic Major Intersections

(1) Improved Problematic Intersections

In the past, there are numerous problematic intersections within the urban areas of Phnom Penh. Intersections of major arterial roads listed in the following table are those whose roadway environment has been significantly improved under the 'Urban Transport Improvement Project in Phnom Penh" from 2007 to 2010.

Table 2.6-1 Major Intersections Improved under the "Urban Transport Improvement Project in Phnom Penh"

Target Intersection	Problems	Countermeasures	Evaluation
Stueng Mean Chey (Monireth/St. 271)	In spite of being an intersection of two major arterial roads with high traffic demand, traffic signal lights were not installed. During morning peak hour, traffic gridlock is very common, whereby total paralysis of traffic is seen.	• Install traffic signals • Install road median, channelization islands • Segregate traffic streams by direction of travel using road markings and traffic signs. • Repair and improve the road pavement	Due to the huge traffic volume, traffic congestion is still visible during certain hours, but peak hour congestion has largely been reduced.
Pet Lork Sang (Russian/St.271/Kampuchea Krom)	An especially problematic cross junction on account of its proximity to a non-signalized Y junction. Traffic congestion is seen throughout the entire day.	• Widen major entry points to the junction • Signalize the Y junction with careful design of signal phasing • Install road median and channelization islands, • Segregate traffic streams by direction of travel using road markings and traffic signs. • Traffic control measures	Capacity is largely increased by the widening works. Careful design of the signal phasing and partial left turn prohibitions have significantly reduced the congestion during peak hours.
Toul Kork (Russian/Mao Tse Toung)	The entry point on Russian is rather narrow resulting in left turning vehicles blocking the opposing through-traffic. In addition, left turning vehicles often intrude into the opposite traffic lane when waiting for the signal to turn green, thus blocking traffic from the opposite direction. These situations caused huge traffic congestions.	• Widen both the entry and exit points on Russian • Install road median • Change the lane with at the entry points	With the installation of extra lanes, wider lane width and the road median, intrusions into the opposite lanes are avoided. Hence traffic congestion has largely been reduced.

Source: PPUTMP Project Team

In addition, further improvements to these intersections in the future may become necessary, involving the construction of grade separated interchanges, traffic safety measures and other major improvements.

(2) Other Problematic Major Intersections That Have Not Been Improved

With the implementation of various measures mentioned in the previous section of the report and the evaluation of these measures presented in the preceding table, much of the traffic congestion problems at the targeted major intersections have been significantly improved. However, intersections with other new problems are still noticeable. In addition to these, there are some other intersections which have been pointed out to be experiencing various problems that require attention. Below are three representative intersections whose problems have been identified and analyzed.

a) Chamkar Morn Intersection
b) Neang Kong Heang Intersection
c) Chrouy Changvar Roundabout

Note: Those in bold boxes are intersections whose problems have been identified.
Source: PPUTMP Project Team

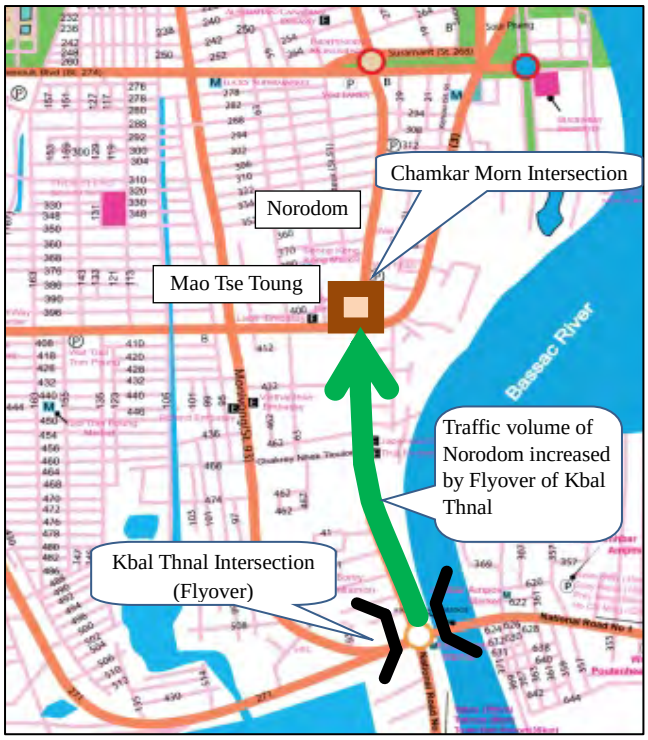
Figure 2.6-1 Location of Problematic Intersections in Phnom Penh

1) Chamkar Morn Intersection

With the grade separation of Kbal Thnal Intersection, northbound traffic volume on Norodom has greatly increased during the morning peak hours. This has caused serious traffic congestion at the upstream Chamkar Morn Intersection. However, it must be noted that the congestion is not so severe as to require waiting for several signal cycles to pass the junction.

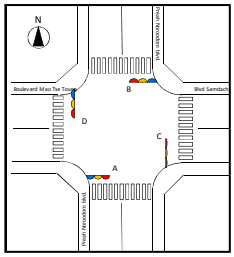
The reason for this situation is the intervention of traffic police on the signal operation at the junction. When directing traffic at the junction during the left turning green phase (36 seconds) for traffic coming from Kbal Thnal, traffic police would use hand signal to gesture the through-traffic to pass the junction. Hence, the green phase timing for through-traffic of 57 seconds has actually been lengthened to 96 seconds.

This unusual traffic control measure is made possible only because the left turning traffic from the direction of the Independence Monument is very light at only 20 vehicles as illustrated in the following figure.
This observation shows that the traffic signal phasing plan applied at this intersection has not been appropriate in response to the actual traffic demand pattern. Therefore, it is necessary to study the traffic demand at this intersection and then revise the signal phasing plan.



Source: PPUTMP Project Team

Figure 2.6-2 Traffic Situation at Chamkar Morn Intersection in Relation to Kbal Thnal Interchange



Phase	1 φ		2 φ		3 φ		4 φ			
Lantern/Stage	1	2	3	4	5	6	7	8		Total
A										
B										
C										
D										
morning (7:00)	57	3	36		32	4	38			170

Source: PPUTMP Project Team

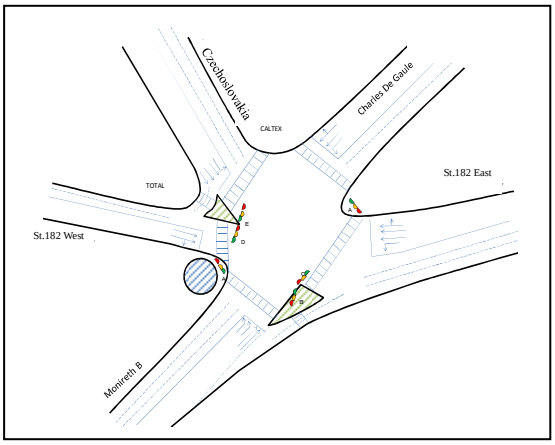
Figure 2.6-3 Existing Signal Timings at Chamkar Morn Intersection

2) Neang Kong Hing Intersection

Neang Kong Heang Intersection is a 5-leg intersection comprising a cross intersection of Monireth-Charles De Gaulle with St.182 as well as the additional road of Czechoslovakia. The two major roads intersect at sharp angles forming an 'X' configuration. For this reason, the existing signal phasing plan is not as simple as that of a normal cross junction.

The problems faced by this intersection are analyzed and described below:

a) The existing signals are complex and difficult to understand,
b) Although congestions are not particularly concentrated at any direction, those on St.182 E are relatively more visible.



Phase	1 ϕ		2 ϕ		3 ϕ		4 ϕ	
Lantern /Stage	1	2	3	4	5	6	7	Total
A	↑→		←					
B			→		↑			
C							←	
D							←↑	
E					↑→		←	
Morning (9:00)	45	4	25	4	45	4	27	154

Source: PPUTMP Project Team

Figure 2.6-4 Existing Signal Phasing Plan and Configuration at Neang Kong Hing Intersection

The flow rates at this intersection are first computed based on the existing traffic volume (peak hour Passenger Car Unit (PCU)) for each signal phase. Through and right turning traffic coming from Charles De Gaulle (Signal Phase 1) has the highest rate of 0.394 followed very closely by the left turning traffic from St.182E (Signal Phase 4) as well as through and right turning traffic (Signal Phase 3) at 0.282 and 0.281, respectively. Finally, the smallest rate of 0.134 is registered by left turning traffic from Monireth.

At this 5-leg intersection, the traffic movements are very complex. The existing signal phasing plan is confusing and difficult to follow as it is not systematic. Moreover, it is obvious that some of the entry points have large loadings due to heavy demand.

As a countermeasure, it is necessary to reduce the loading on the entry point at Charles De Gaulle. Under the existing condition, if widening of entry points to the intersection is in fact difficult to achieve, then some other form of traffic control measures will become necessary.

3) Chrouy Changvar Roundabout

Chrouy Changvar Roundabout is regarded as the gateway from the North East to the city of Phnom Penh. It has direct regional links to Thailand and Siem Reap via NR5 and NR6. It is also a major node on IRR which forms the backbone to the city's road network structure. This roundabout is therefore an important traffic node that receives large impacts from the city's urban traffic flows.
Chrouy Changvar Roundabout has a diameter of 100 m. It is the second largest roundabout in the city, after the 220 m diameter roundabout of Wat Phnom.

Traffic passing through this roundabout on IRR has to maneuver either on the minor arc (from the west towards the south) or on the major arc (from the south to the west). On the minor arc, the southbound traffic has only one merging point with the other traffic streams. However, on the major arc, the westbound traffic would face 5 other merging traffic flows. With such numerous merging points within short sections of the roundabout, and given that traffic demand is high, this roundabout is experiencing safety and smooth traffic flow issues.

In passing through the roundabout on IRR, the minor arc is only 60 m while the major arc is 4 times longer. Traffic in the roundabout has to change lane frequently resulting in many weaving traffic movements. Generally, it is more desirable to have shorter travel distances within an intersection.

It is foreseeable that with population increase in the future, traffic demand will also increase. In the near future, when the 'Japanese Bridge' is widened from the existing 2 lanes to a 4-lane highway, traffic volume will surely increase, bringing a much larger traffic loading onto this roundabout in the future.

To strengthen the inner city functions and to promote smooth traffic flow on IRR, it is therefore necessary to control local through-traffic as well as to disperse them in a more effective manner. For this reason, some forms of traffic countermeasures are necessary to reduce the numerous merging traffic problems on the major arc of this roundabout.

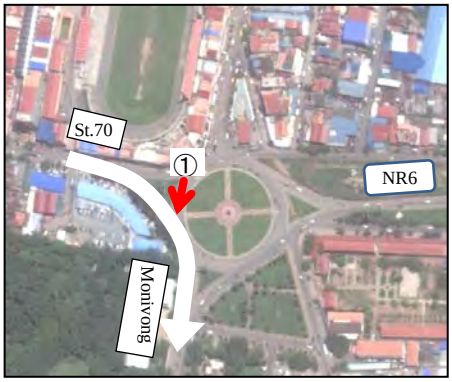
Source: PPUTMP Project Team

Figure 2.6-5 Location of Chrouy Changvar Roundabout on IRR

Table 2.6-2 Disturbances to Traffic on IRR at Chrouy Changvar Roundabout

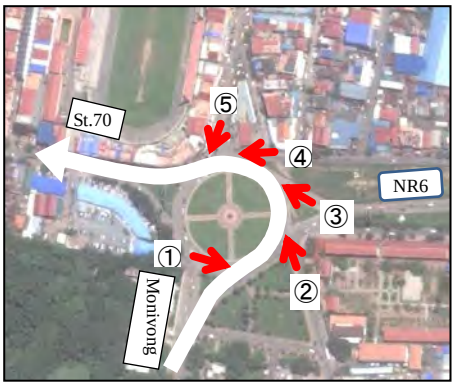
Section	Merging points	Travel distance
Minor arc (southwest section)	1	60 m
Major arc (northeast section)	5	230 m

Source: PPUTMP Project Team



Source: PPUTMP Project Team

Figure 2.6-6 One Merging Point on the Minor Arc



Source: PPUTMP Project Team

Figure 2.6-7 Five Merging Points on the Major Arc

2.6.2 Traffic Signal System

As of January 2013, there are a total of 69 signals operating in PPCC. The location of existing signals is shown in Figure 2.5-8. As shown in the figure, most of them are installed along major streets. The signals are relatively new as they were only installed in 1999.

A variety of equipment is found in the signal system. As shown in the map of traffic signals, the signal controllers came from different countries including China, Taiwan, Vietnam, Japan, Thailand and Germany; the signal lanterns from China and Vietnam; and the signal cables from China, Vietnam and Thailand. Only the signal poles are manufactured locally. A large variety of signal types indicate that signals were installed on an ad hoc basis without consistent design and long-term plan. A mixed variety of signals is a cause of problems described below.

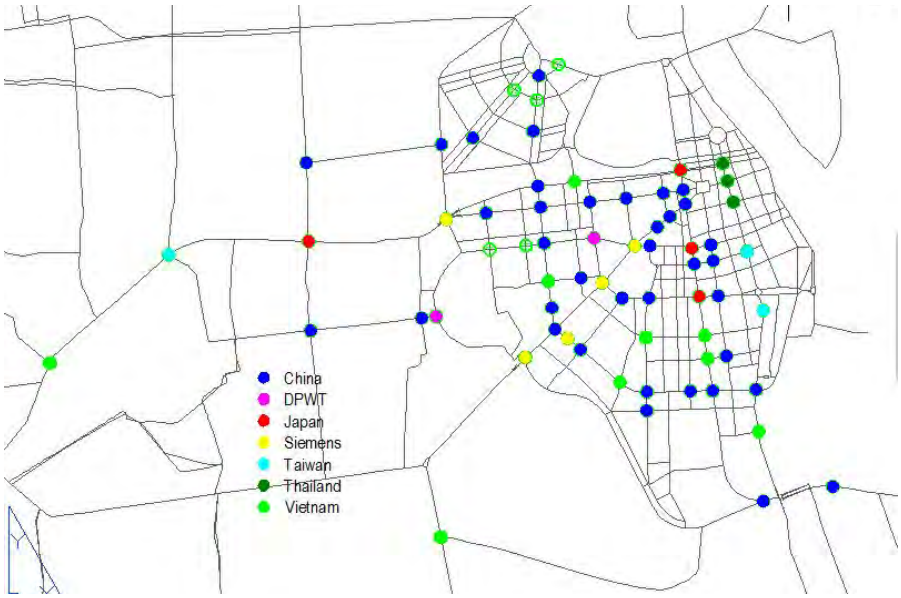
(1) Inflexible Signal Timing Parameter

Most of the existing signals are fixed time signals applying a single timing parameter set regardless of traffic condition, time of day, and day of the week. Traffic condition is normally heavy during peak hours and light during night time and on Sundays and holidays. If signal timing is designed to meet high demand during peak hour traffic condition, it is not suitable for off-peak hour traffic when traffic is light. If the timing is designed for off-peak hour traffic, it is not effective in handling the peak hour traffic and congestion will occur. As a result, the signal operation is far from efficient most of the time.

Some of the local controllers are provided with Time-of-Day (TOD) control function however. Different signal timing parameter sets are stored in the local controller and the local controller has a clock. One of the timing parameter sets is selected and applied according to the time of day and day of the week in TOD control. Intersections with TOD local controller are:

- Preah Monivong - Tep Phan
- Preah Monivong - Russian
- Russian - St. 271
- Monireth - St. 271

The TOD function of these local controllers is, however, not properly set so that their capability is not effectively utilized.

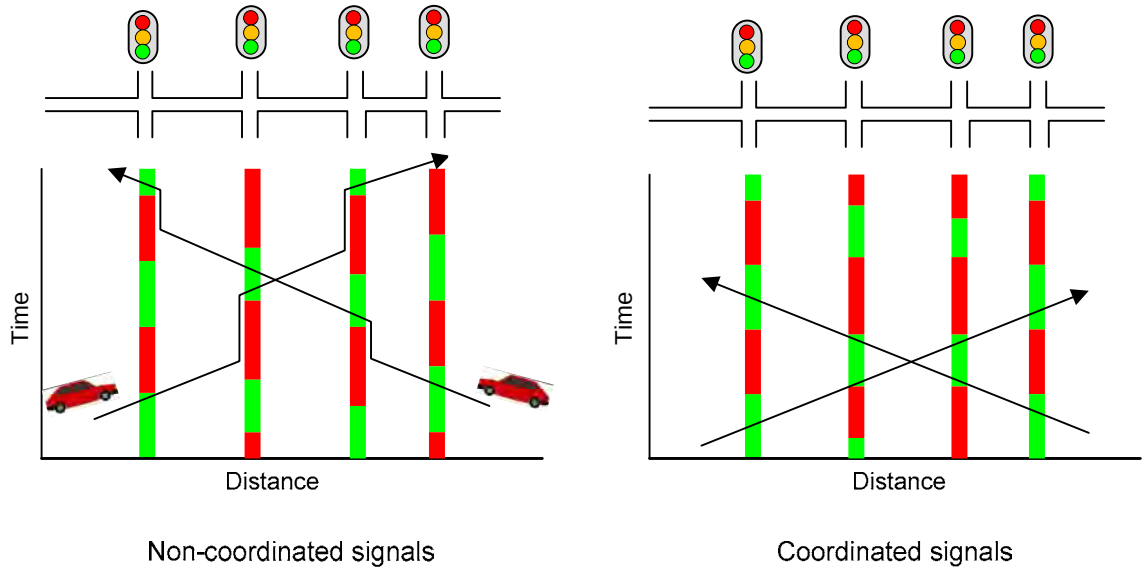


Source: PPUTMP Project Team

Figure 2.6-8 Existing Traffic Signals in PPCC

(2) Isolated Operation

All signals in the city are isolated signals operating independently without coordination with neighboring signals. In urban areas like CBD of Phnom Penh where intersections are closely located and traffic volume is relatively high, signal operation becomes inefficient if they are not coordinated and vehicles are required to stop at every signal. The figure below shows the difference of coordinated signals and non-coordinate signals.



Source: PPUTMP Project Team

Figure 2.6-9 Signal Coordination

(3) Inadequate Phase Sequence and Timing Parameter

Observation of the existing signals and traffic flow revealed that the phase sequences (order of green signal to different approaches) and their duration are not optimized. As a result green time is often wasted creating unnecessary delay and reducing intersection capacity. Signal operation can become more efficient if phase sequence and timing parameter are adjusted and optimized even for fixed time local controllers.

(4) Weak Signal System Management Capability

The Public Lighting Division of DPWT is in charge of the design, installation, operation and maintenance of signal systems. The Division has a total staff of 30 persons and 5 of them are assigned to the signal system.

There are no standards or guidelines for signal design. It seems that when a new signal is required, signal is designed in a heuristic manner, that is, without following established design procedures. The result would be a signal design not optimized for traffic condition at the intersection.

No intersection signal design drawing, which is the most basic design drawing, is available in the aforementioned division. The list of existing signals and map of existing signal locations are not updated and they are not consistent with each other. Only cycle time data is available at the Division and no phase sequence and timing parameter set are kept. Lack of these basic data indicates that management of traffic signal operation and maintenance are very poor and need upgrading.

(5) Other Features of the Existing Traffic Signal

LED-type vehicle lanterns are used for all signals except a few locations. They are generally in good condition. Arrow signals in green, yellow and red are used in Phnom Penh. Use of arrow signals is an effective way to control movement in different directions separately by indicating the direction of flow by an arrow.

A countdown timer is provided to the signal at major intersections. It is expected to indicate the remaining time of green or red display so that drivers can be prepared for signal change. It is noted, however, that the countdown timer uses the display duration of previous signal cycle measured by the timer as the duration for next cycle. It does not know the expected duration of the signal currently displayed. If the signal indication duration is variable due to actuation control, central control or manual control, the duration would fluctuate every cycle and the countdown time cannot display the exact time remaining.

No vehicle detector is used to adjust signal timing according to the traffic volume or vehicle arrivals. Thus all signals are not responsive to the varying traffic demand. No closed circuit television (CCTV) camera is installed at intersection to observe traffic condition.

2.6.3 Other Traffic Control Devices and Measures

The photo below shows the typical arrangement of traffic control devices at an intersection in Phnom Penh. Some features of traffic management devices are presented below.

Source: PPUTMP Project Team

Figure 2.6-10 Typical Arrangement at Intersection

(1) Pavement Markings

Roads in Phnom Penh can be divided into two types in terms of pavement markings: roads with good pavement markings and roads without pavement markings. Pavement markings, if they exist, are relatively in good condition as shown in the photo.

(2) Center Divider

A center divider made of concrete blocks is placed along the center line of the main road as physical barrier separating movements of two opposimg directions. The divider has two functions. It prevents vehicles, in particular motorcycles, encroaching on the other side of the road. Such action not only hampers the traffic flow of opposite direction but also creates very dangerous situation. The divider also works to prevent the vehicles coming out of an alley from making a left turn crossing the near side of the traffic stream.

A directional sign instructing drivers to take the right side of the divider is provided at both ends of the divider. At some locations, a directional sign with LED lights arranged around the sign periphery and along the diagonal line indicating prohibition is provided. The sign is provided with solar-powered night light.

(3) Sidewalk Parking

As the photo shows, sidewalk of main road is converted to parking space. The practice is effective in eliminating the blockage of flow caused by the roadside parking. But pedestrian walking environment is greatly affected. The sidewalk is for pedestrians. In addition, it functions as buffer zone between carriageway and roadside facilities. The function is compromised when the sidewalk is used as parking space. Considering the fact that the number of parking spaces gained is small and they are used by only a very limited number of users, a long-term solution for parking management must be developed and implemented.

2.6.4 Inefficient Utilization of Roads

(1) Illegal Use of Urban Transport Space

It is common to see passenger cars and motorcycles parked at road corners, on the sidewalks or even within the intersections. There are also multiple rows of parking in front of popular restaurants or famous hotels. The parking problem in Phnom Penh has undoubtedly decreased the road capacity and it is also one of the major reasons for the serious traffic congestion experienced daily in the city. With recent increases in car and motorcycle ownerships, this situation will become more severe during the day and further reduce the overall efficiency of the city's road network.

The sidewalk encroachment by parking vehicles has also caused significant risks to pedestrians as they are left with no choice but to walk on the roadway. In addition, the haphazard manner by which vehicles are parked on the sidewalks and roads has adversely affected the aesthetics of the city's landscape.

The vehicle parking problem in PPCC is clearly going to become a major urban transport issue that will adversely affect the growth of its economy, tourism and other major industries as well as the quality of daily lives of urban residents in the near future. It is hoped that the city government, the police force and other related governmental agencies can work closely together to plan with a long-term perspective and carry out a series of comprehensive overall countermeasures to overcome this pressing problem.

(2) Indifferent Behavior of Drivers toward Traffic Rules

The "Cambodia National Road Transport Law" was enacted in 2006 which provides the basic rules governing road transport and traffic operation. If all the citizens are able to observe the transport laws and traffic rules outlined here, there will be little problems for the city government. But in reality, many drivers do not obey the existing rules and laws.

1) Travel Behavior on Single Carriageway

All vehicles are required by law to travel on the righthand side of any roads. On two-way roads that have no surface markings, drivers are required to keep to the right at all times. However, during the morning peak hours and especially on roads having no central median, drivers are commonly seen to travel on the center line or even encroach on the opposite lane. Such behavior causes serious accident and brings danger to other road users.

2) Travel within Intersection

When faced with a red signal at an intersection, all vehicles must stop behind the stop line. However, it is very common to see motorcycle drivers stopping their vehicles beyond the stop line and on the pedestrian crossing. Volunteers have to be deployed in the city to provide guidance to such errant drivers at all time.

At intersections without a road median, left turning vehicles are often seen to go beyond the center line and stop on part of the opposite lane causing the narrowing of the exit point of the intersection. This irresponsible behavior thus has created severe congestion on the opposing traffic stream. Similarly, even at intersections having road median, it is the motorcycles that often behave badly by stopping beyond the stop line and on the opposing lane causing severe congestion.

Even though left turning vehicles must give way to the opposing through-traffic as the latter has the right of way, in many cases, left turning vehicles would aggressively force their way through the oncoming traffic, thus forcing the opposing through-traffic to stop in the middle of the intersection. Furthermore, when faced with congestion, vehicles on the through lane would also make illegal left turns.

3) Others

Other traffic offenses frequently seen are as follows:

- Travel in the opposite direction on one-way traffic roads
- Illegal parking (on roads and sidewalks)
- Driving without helmet
- Carry more than the legally allowed number of passengers

These traffic offenses can be seen daily and they have produced adverse effects on the safety and smooth functioning of roads in the city. It is very important to intensively conduct enforcement on these offenses while at the same time improving on the city's transport infrastructure.

2.6.5 Deteriorating Parking Situation in Phnom Penh

The following is an analysis on the existing parking situation (balance of parking demand and supply) in the city center of Phnom Penh based on results of actual on-site survey.

(1) Parking Demand

Demand for on street parking is summarized below.

Table 2.6-3 Demand for On-street Parking

Motorbike

	Actual	Estimate	Total
Block_1	1,817	2,605	4,422
Block_2	1,326	1,409	2,735
Block_3	1,126	648	1,774
Block_4	310	0	310
Block_5	2,878	1,619	4,497
Block_6	0	1,820	1,820
Total	7,457	8,102	15,559

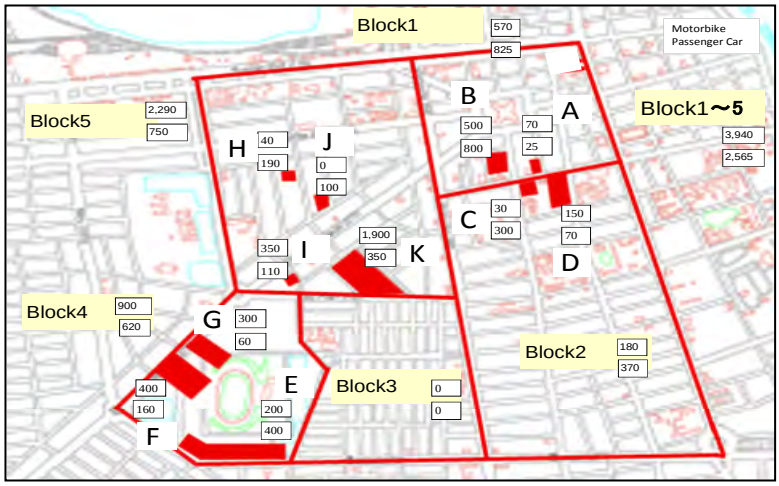
Passenger Car

	Actual	Estimate	Total
Block_1	1,290	1,495	2,785
Block_2	876	1,040	1,916
Block_3	690	400	1,090
Block_4	185	0	185
Block_5	1,107	571	1,678
Block_6	0	752	752
Total	4,148	4,258	8,406

Source: PPUTMP Project Team

(2) Demand for Off-street Parking Facility

Parking demand at off-street parking facilities are based on surveys at 6 relative large off-street parking facilities, selected out of the 11 parking facilities located within the targeted blocks.



Source: PPUTMP Project Team

Figure 2.6-11 Location of Off-street Parking Facilities

1) Parking Demand at All Parking Facilities

Parking demand at all the off-street parking facilities within the survey blocks are as follows:

Table 2.6-4 Parking Demand at all Parking Facilities

		Name of parking facility (if any)	Actual survey value		Estimated value		Total	
			Motobike	Passenger Car	Motobike	Passenger Car	Motobike	Passenger Car
	A	SN	-	-	9	1	9	1
○	B	Sorya Shopping	130	38	-	-	130	38
	C	Coffee Mondul Kiri	-	-	4	13	4	13
	D	Sorya mall	-	-	18	3	18	3
○	E	Underground	7	7	-	-	7	7
○	F	City mall	70	16	-	-	70	16
	G	Olympic Stadium	-	-	37	3	37	3
○	H	Chey Thavy	26	4	-	-	26	4
○	I	Home Center	5	2	-	-	5	2
	J	Serey Pheap	-	-	0	4	0	4
○	K	Ou Russei Market	180	18	-	-	180	18
		Total	3,940	2,565	136	47	477	109

○:Implementation of parking demand survey

Source: PPUTMP Project Team

2) Parking Demand by Block

The total parking demand for on-street parking and off-street parking facilities for passenger cars and motorbikes by block are summarized below.

Table 2.6-5 Motorbike Parking Demand

Block	Existing Parking Demand		
	On-street	Off-street	Total(A)
1	4,422	139	4,561
2	2,735	22	2,757
3	1,774	0	1,774
4	310	114	424
5	4,498	211	4,709
6	1,821	0	1,821
Total	15,560	486	16,046

Table 2.6-6 Passenger Car Parking Demand

Block	Existing Parking Demand		
	On-street	Off-street	Total(A)
1	2,785	39	2,824
2	1,916	16	1,932
3	1,091	0	1,091
4	185	26	211
5	1,679	28	1,707
6	752	0	752
Total	8,408	109	8,517

Source: PPUTMP Project Team

(3) Parking Space at Off-street Parking Facility

Within the survey blocks, the total parking spaces for motorbikes at all the off-street parking facilities are estimated at about 3,900 spaces, while for passenger cars, the total is estimated at 2,600 spaces.

Table 2.6-7 Parking Spaces by Block

		Name of parking facility (if any)	Type of parking	Number of parking space		Number of parking space		Block No
			1. At grade 2. Under ground	Motobike	Passenger Car	Motobike	Passenger Car	
	A	SN	1	70	25	570	825	1
○	B	Sorya Shopping Center	1	500	800			1
	C	Coffee Mondul Kiri	1	30	300	180	370	2
	D	Sorya mall	1	150	70			2
○	E	Underground Parking	2	200	400	900	620	3
○	F	City mall	1 & 2	400	160			3
	G	Olympic Stadium	1	300	60			3
○	H	Chey Thavy	1	40	190	2,290	750	5
○	I	Home Center	1	350	110			5
	J	Serey Pheap	1	0	100			5
○	K	Ou Russei Market	1	1,900	350			5
			Total	3,940	2,565			

○ : Implementation point of demand survey

Source: PPUTMP Project Team

(4) Evaluation

In examining the present parking demand and supply balance within the overall survey blocks, even if all the off-street parking facilities are 100% used, there is still a total deficit of 12,000 vehicles for motorcycles and more than 6,000 vehicles for passenger cars. By looking at the parking balance by block, Block 1 which has the Central Market shopping area is facing the biggest deficit. This is chiefly due to the fact that even though this Block 1 is located in the center of the city, it has no public transport facilities and a significant shortage of off-street parking spaces of more than 4,000 spaces for motorcycles and 2,600 spaces for cars.

Analytical results from the parking survey such as this have clearly revealed the fact that there is a serious shortage of parking facilities in the city center of Phnom Penh and which has directly led to the unlawful rampant parking on the streets and sidewalks. In addition, considering the increasing population trend, it is foreseeable that parking demand will also increase rapidly in the future.

Therefore, a comprehensive parking policy and countermeasures are necessary both from the soft and hardware perspectives.

Table 2.6-8 Existing Parking Demand-Supply Balance

The parking supply and demand balance of the current state for moterbike

Block	Existing Parking Demand			Parking Spase	A-B
	On-street	Off-street	Total(A)	(B)	
1	4,422	139	4,561	570	3,991
2	2,735	22	2,757	180	2,577
3	1,774	0	1,774	0	1,774
4	310	114	424	900	-476
5	4,498	211	4,709	2290	2,419
6	1,821	0	1,821	0	1,821
Total	15,560	486	16,046	3,940	12,106

The parking supply and demand balance of the current state for passenger car

Block	Existing Parking Demand			Parking Spase	A-B
	On-street	Off-street	Total(A)	(B)	
1	2,785	39	2,824	825	1,999
2	1,916	16	1,932	370	1,562
3	1,091	0	1,091	0	1,091
4	185	26	211	620	-409
5	1,679	28	1,707	750	957
6	752	0	752	0	752
Total	8,408	109	8,517	2,565	5,952

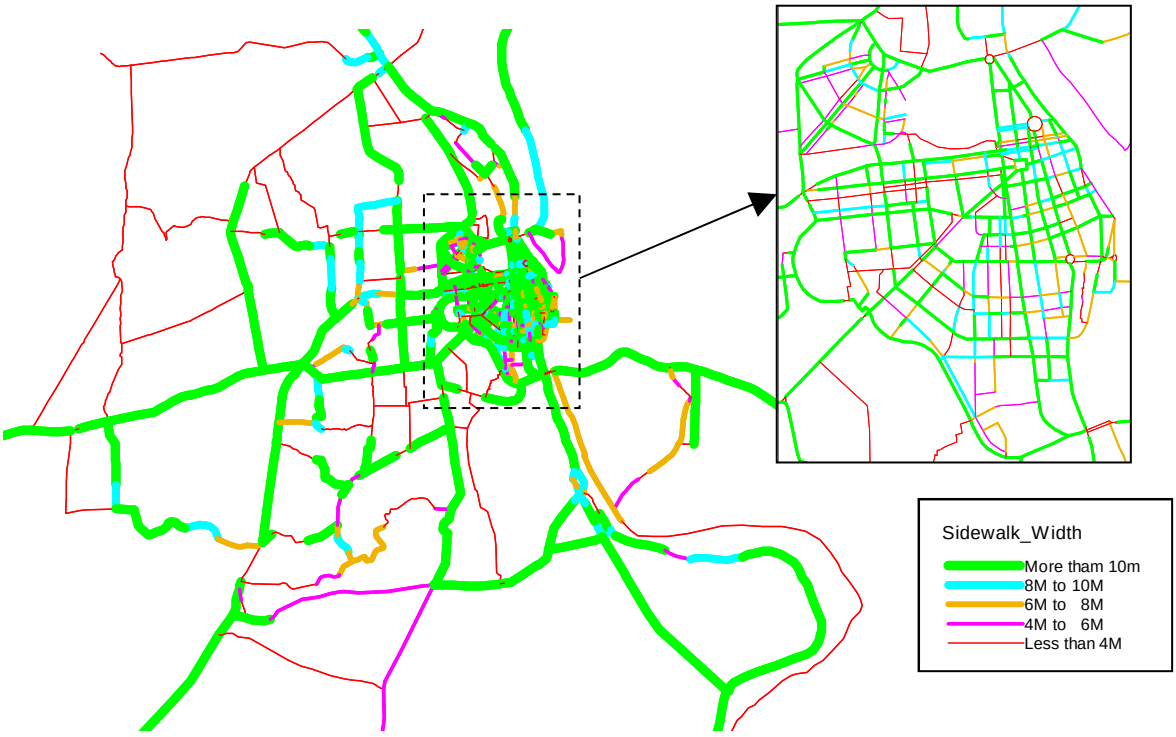
Source: PPUTMP Project Team

2.6.6 Poor Pedestrian Environment

(1) General Pedestrian Sidewalk Environment in Phnom Penh

According to the results of the road inventory survey, there are many arterial roads within PPCC that have pedestrian sidewalks 10 m and more in width. However, most arterial roads at the outskirt of the city have only 4 m sidewalks. Even within the city center, there are still some road sections with only 4 m and less.

Referring to the comments from pedestrians in the pedestrian survey, the sidewalks before the Public Experiment were perceived as 'Difficulty of walking due to illegal parking" (98.1%) and 'Difficulty of walking due to on-street vendors' (86.3%).



Source: PPUTMP Project Team

Figure 2.6-12 Conditions of Pedestrian Sidewalks in Phnom Penh

(2) Pedestrian Sidewalk Environment in the City Center

Within the city center, the pedestrian sidewalk environment requires a more detailed observation. Using the Public Experiment coverage area as a reference, the target area for the study is an area that witnessed a high usage of sidewalks by foreign tourists. This area is defined by Wat Phnom, Central Market, River Side, St.178, the National Museum, the Royal Palace (and Silver Pagoda), St.240, the Independence Monument, Boeng Keng Kang Area, and the Toul Sleng Museum.

1) Sidewalk Environment

It is found that sidewalks around Wat Phnom, the National Museum, the Royal Palace (and Silver Pagoda) and the Independence Monument are relatively wide and comfortable to use but those around Central Market and the Toul Sleng Museum are rather difficult to walk due to the presence of illegally parked vehicles and their usage for terrace table seats by cafés and as display spaces by adjoining shops.

Pedestrian sidewalk with wide walking spaces

Many sidewalks in the city center are occupied by illegally parked vehicles

Many sidewalks are also being used as outdoor seating area by coffee shops

Source: PPUTMP Project Team

Figure 2.6-13 Sidewalk Environment Situation in Phnom Penh

2) Major Roads

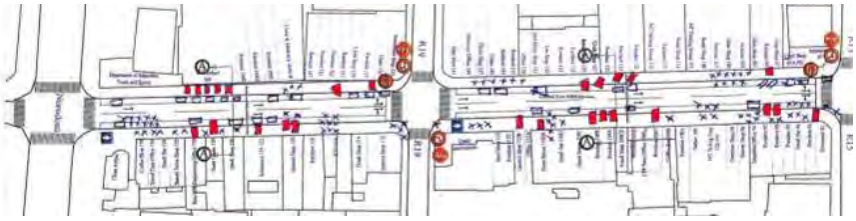
Norodom and Monivong are two very representative major arterial roads in the city center. The sidewalks along Norodom are wide with very few illegally parked vehicles. A continuous sidewalk environment is available along this street.

On the other hand, there are sidewalks in front of many shops and restaurants on Monivong that are commonly used as parking spaces.

3) Local Roads

Illegal Parking on the Sidewalk
Although there are many cases where sidewalks are being occupied by illegally parked vehicles, there are still some cases where sufficient spaces are still available for the use by pedestrians.

The following figure shows an example of illegal parking situation on the sidewalks within the coverage area of the Public Experiment before the event. The 'red' markings are illegally parked vehicles. All these illegally parked vehicles are observed to have parked in perpendicular pattern to the roadway.

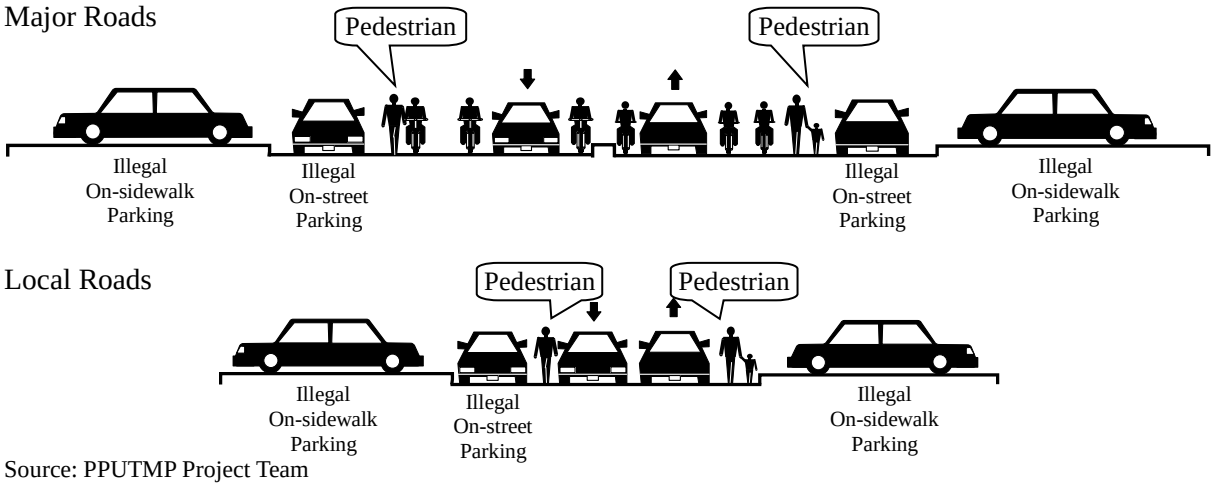


Source: PPUTMP Project Team

Figure 2.6-14 Illegal Parking Situation on the Sidewalk in Phnom Penh

Outdoor Seating and Merchandise Displays on the Sidewalk
There are also many cases where the sidewalks are being used for outdoor terrace table seats by adjoining coffee shops or as part of the shop spaces by businesses along the road. Among these, however, there are cases where the sidewalks are totally occupied and those that some sizeable spaces are still left over for walking. Similarly, although some sidewalks are used for display of merchandise or as a terrace for potted plants by residents, there are cases where some spaces are still available for walking.

Walking Environment Near to Tourist Spots
Large pedestrian movements are found between the popular tourist spots such as Wat Phnom, Riversides, the Royal Palace (and Silver Pagoda) around the Riverside District. However, such movements are scarce via the Central Market. One of the possible reasons for this phenomenon is the rampant illegally parked vehicles which have occupied the sidewalks making them unsafe and uncomfortable to walk.



Source: PPUTMP Project Team

Figure 2.6- 15 Unsafe and Uncomfortable Walking Environment in the City Center

(3) Sidewalk Environment Problems/Issues

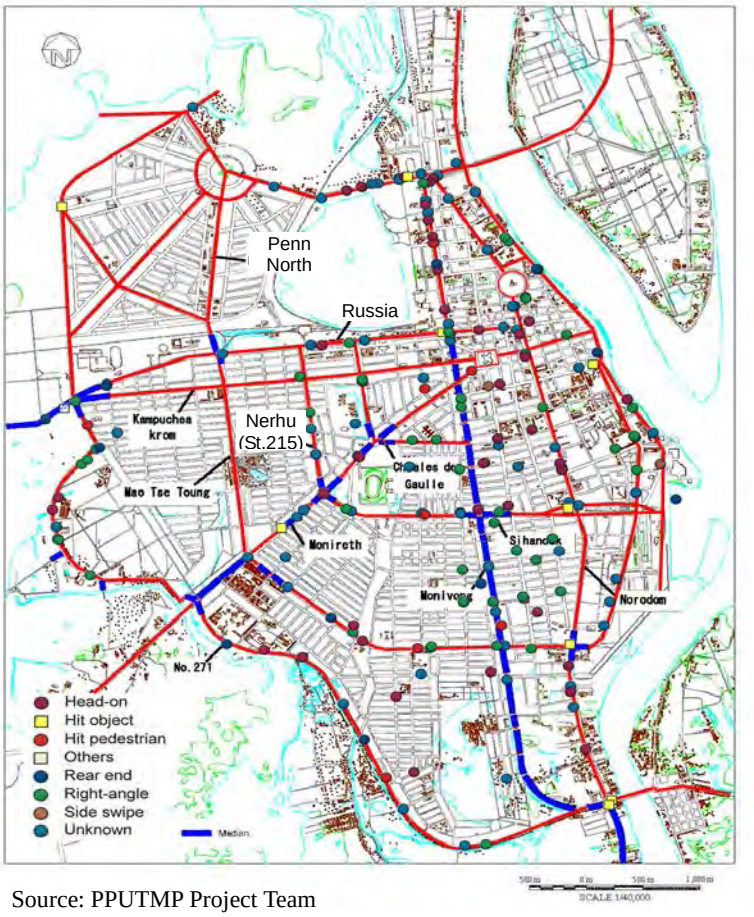
Thus the following problems and issues on pedestrian sidewalks are identified:

- Phnom Penh is a city that has relatively wide sidewalks on account of its French colonial heritage. Unfortunately, most of the sidewalks are now occupied by illegally parked vehicles, outdoor café seating, merchandise display and planters, making walking on these sidewalks rather difficult and not conducive for this activity.
- For this very reason, pedestrians have no other choice but to walk on the roadways, making such situations very dangerous to the pedestrians.
- For foreign tourists who move about on foot most of the time, this situation has rendered the city streets rather unattractive to visit and the walking environment rather poor.

2.6.7 Increases in Traffic Accidents

(1) Existing Situation on Traffic Accident

The capital city of Phnom Penh is experiencing an unprecedented rate of urbanization and population increases brought about by rapid economic growth. As a result, vehicle ownership rates, both passenger cars and motorcycles, are on the increase. This has put great pressure on the urban transport infrastructure leading to a general deterioration of urban transport environment. In recent years, severe traffic congestion and traffic accidents have in fact become major social issues. To understand the traffic accident situation, the following gives a general outline on the 196 cases of traffic accidents which occurred in 2007 within the city center area as defined by IRR, Sisowath, Norodom and other major roads.



Source: PPUTMP Project Team

Figure 2.6-16 Distribution of Traffic Accident Occurrence in Central Area of Phnom Penh

(2) Importance of Drivers Education

The special features of traffic accidents in Phnom Penh are summarized as follow:

a) Almost half of the accidents are due to over speeding by drivers.
b) Many accidents are observed to happen at night, where drunken driving is a major occurrence.
c) By type of vehicles, motorcycles are involved in almost 90% of the total traffic accidents.

It is a said that most traffic accidents occur because of a combination of various factors, ranging from road environment, weather conditions, driver behavior and roadworthiness of the vehicles. The topography of the city center of Phnom Penh is relatively flat, and except for a small area, there are no sharp curves or steep gradients. Therefore, road alignment is almost not an issue that may affect the traffic safety in this city.

On the other hand, the urban population of Phnom Penh is expected to increase rapidly in the near future. With this increase in urban population, there will be a fast increase in the number of new drivers as well. The higher the proportion of new drivers among the city's total number of drivers, the higher will be the risk in causing traffic accidents. Like many developing countries in the region, driving licenses are often issued without imparting sufficient driving knowledge, skills and training to these new drivers. Furthermore, it is commonly observed that many people in Phnom Penh are driving even without obtaining the valid licenses.

The background stated above showed that most of the traffic accidents in Phnom Penh are caused largely by overspeeding, drunken driving and other factors relating to the drivers themselves. In observing the traffic operation and behavior, motorcycles in particular are found to frequently flaunt traffic rules, such as making left turns before the intersections as they can easily maneuver the small turning radius; overloading of passengers or goods, traveling in the opposing direction on designated one-way traffic flows and others. Such unlawful behaviors are the direct causes of high traffic accident rates among the motorcycles.

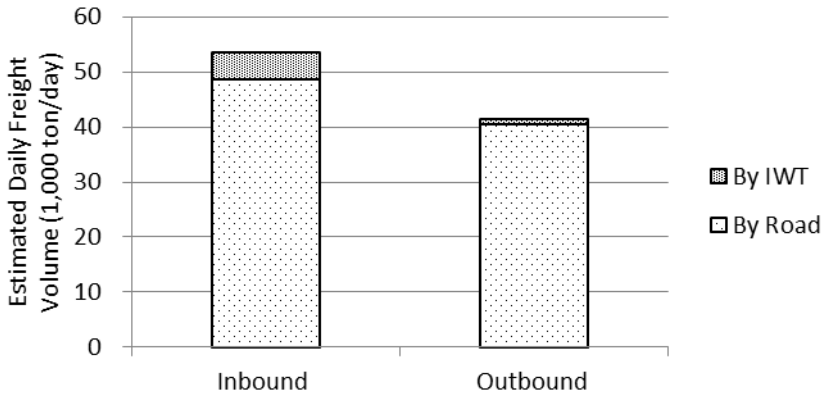
It is therefore important for the city government to improve the level of traffic safety by first ensuring the smooth flow of traffic as well as overcoming the issue of providing effective driver education especially the mandatory driving education before issuing valid driver licenses to the citizens of Phnom Penh.

Finally, driver education and enforcement must also go hand in hand to producing the desired effects. Thus, training and nurturing of enforcement officers is also an important measure that needs to be taken by the government.

2.7 Commodity Flow

The study area includes Cambodia's capital city Phnom Penh, which has a population of 1.5 million. Phnom Penh is also an industrial center with the Phnom Penh Special Economic Zone (PPSEZ) and two industrial parks located there. In the study area is found the second largest port in Cambodia, namely, Phnom Penh Port along the Tonle Sap River (as of 2012); therefore, it produces and attracts a considerable volume of cargo. Based on the result of the cordon line survey in June 2012, annual average daily incoming and outgoing cargo volume by road were estimated at 48.5 thousand tons per day and 40.4 thousand tons per day including through-cargo with 5.0 thousand tons, respectively.

On the other hand, annual export and import cargo volume including fuel and gas at existing Phnom Penh Port in 2011 were 244.2 thousand tons and 1.3 million tons (4.9 thousand tons per day and 0.9 thousand tons per day), respectively. Thus, more than 90% of cargo relevant to Phnom Penh is transported by road transport, namely, trucks.

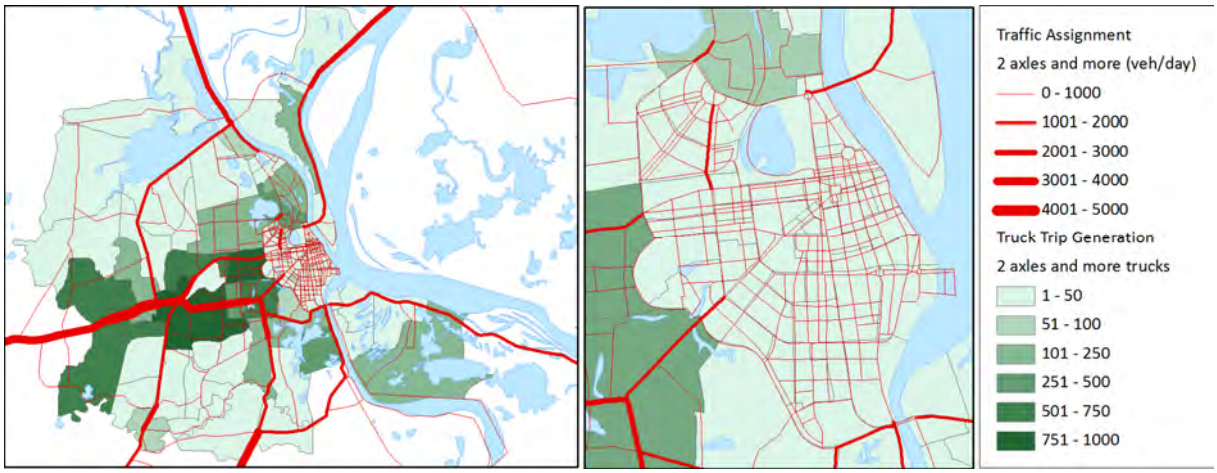


Note: Freight volume by truck is estimation based on cordon line survey in June 2012. Freight volume by inland water transport is actual value by statistics of Phnom Penh Port Autonomous in 2011.
Source: PPUTMP Project Team

Figure 2.7-1 Estimated Annual Average Daily Freight Volume through Cordon Line

The following figure shows estimated current truck trip generation in Phnom Penh and results of truck traffic assignment in 2012. Truck trip generation was estimated by generation model built by the results of cargo facility interview survey at Phnom Penh Port, 4 dry ports/warehouses and 10 industries in Phnom Penh, while assigned truck Origin-Destination (OD) was estimated by gravity model based on the truck driver interview survey at cargo facilities.

Remarkable truck trip generation was observed at zones with large-scale industries such as dry ports and industrial parks along Chaom Chau Road, and PPSEZ along NR4. And truck traffic volume at radial arterial roads such as NR1, NR2, NR3, NR4, NR5 and NR6, especially NR4 connecting with Sihanoukville and Chaom Chau Road, are remarkable.



Source: PPUTMP Project Team

Figure 2.7-2 Estimated Trip Generation and Assigned Volume of 2 Axles and more Trucks in 2012

2.7.1 Truck Traffic in Suburban Area

Chaom Chau Road is an access road for industries and dry ports and also a connecting link between Phnom Penh Port, NR1, NR2, NR3 and NR4. Therefore, a considerable number of heavy trucks pass through Chaom Chau Road. According to the traffic count survey in June 2012, the volume of trucks of more than 2axles exceeded 2,000 in both directions in 16 hours.

Problems concerning truck traffic are identified by observation and analysis of Chaom Chau Road, which is representative of the existing freight transport route in the study area.

(1) Mix Traffic of Freight Transport and Daily Traffic

There are not only dry ports and industries but also a village and market along Chaom Chau Road, and the mix traffic of freight transport and daily traffic presents a complication that reduces the safety and service level of the road.

(2) Damage of Road Surface Caused by Truck Traffic

On Chaom Chau Road, not a few potholes are found or water pooling along the shoulder even in dry season. Those defects reduce the level of service of the road, and road safety. Chaom Chau Road is operated by a private company and tolls are collected only from trucks for the road maintenance. Currently, however, above defects are found and road maintenance is insufficient.

(3) On-street Loading/Unloading

On-street loading/unloading of trucks at the road section with insufficient shoulder or sidewalk is often observed, and this obstructs other through-traffic and causes reduction of level of service of road and road safety.

(4) Insufficient Road Width and Lane

Basically, Chaom Chau Road is a two-way two-lane road; and traffic begins to build up as heavy trucks travel at reduced speeds on the damaged road surface sections.

2.7.2 Truck Traffic in the City

On radial arterial roads at the edge of Phnom Penh's urban area, such as Russian, a vehicle height limit is enforced in order to prohibit passage of heavy trucks in the city during peaks hours (5:00 - 21:00). Therefore, few permitted heavy vehicles are found in the city center in daytime.

Freight transport in the city is mainly done by 2 axles truck (maximum loading capacity 2 tons and less), pick-up/vans and 2 - 3 wheels motorcycles.

(1) On-street Loading/Unloading at Arterial Road

Even on the arterial road with enough sidewalk and shoulder in the city, some trucks stop on the carriageway and load/unload goods. Because off-street parking space for loading / unloading such as sidewalk or shoulder in front of retail

shops/wholesalers/warehouses were occupied by other parked vehicles or shop merchandise. This on-street loading/unloading of trucks obstructs traffic flow and causes traffic congestion. In addition, those parked trucks make blind spots and reduce traffic safety.

(2) On-street Loading/Unloading at Street

At the collector/minor road or street, on-street loading/unloading trucks on the carriageway are frequently found because of insufficient off-street parking space. Most of those streets have 2 lanes for 2-way direction and no shoulder, thus, a loading/unloading truck occupies one lane and obstructs traffic flow.

(3) Insufficient Off-street Space at Large-Scale Buildings

At some large-scale buildings such as shopping centers, on-street loading/unloading is observed because of insufficient off-street parking space near the dock/entrance on the premises. On-street parking obstructs other passing traffic and pedestrians.

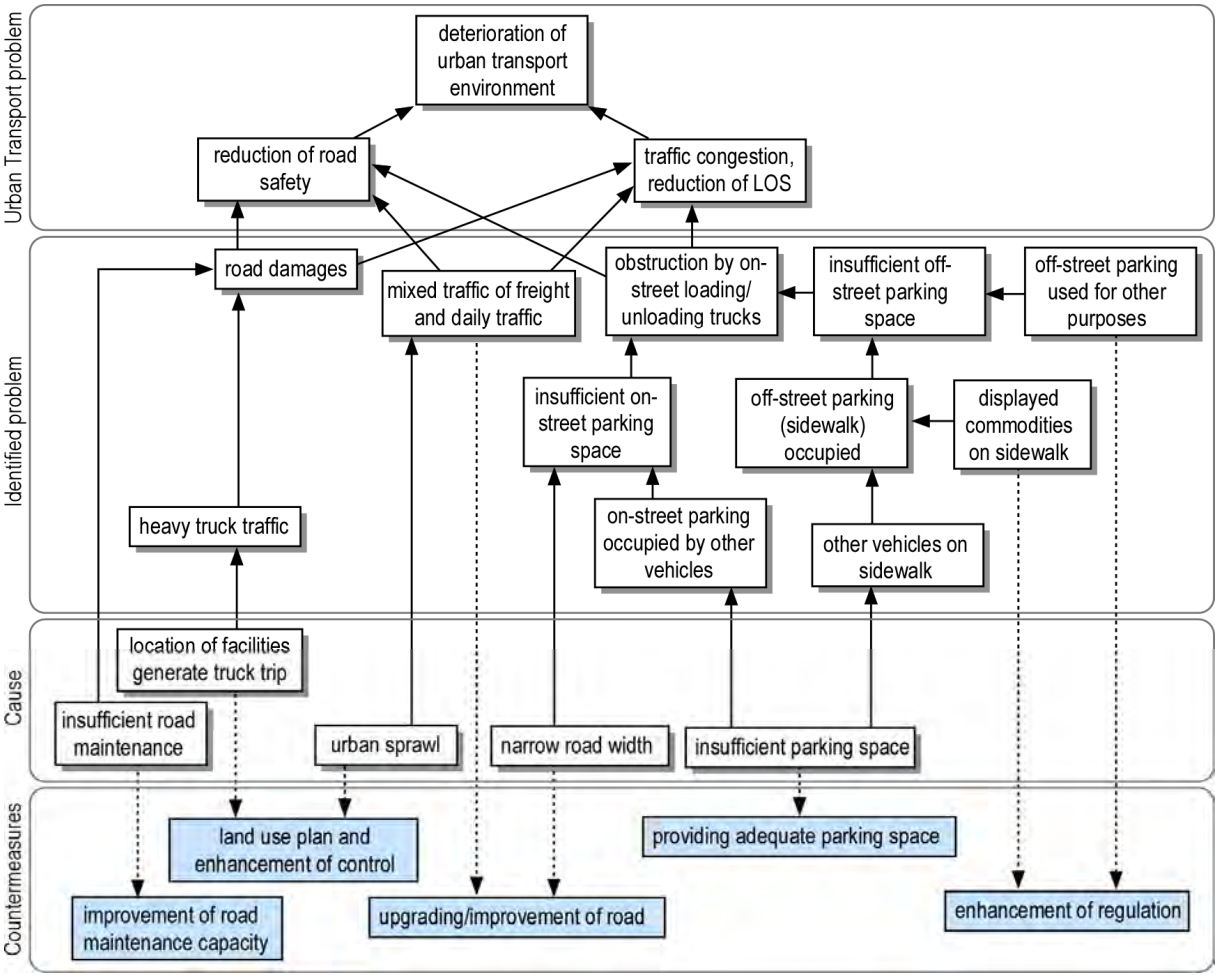
(4) Usage of Off-Street Parking for Other Purposes

Most of the local markets in the city center have off-street parking space for loading/unloading trucks not only for customers. However, a part of parking space is often occupied by a stallholder or food stand. It causes traffic congestion not only at the off-street parking but also the surrounding access road of the facility.

2.7.3 Problems and Issues of Current Truck Traffic

Identified existing problems of truck transport are summarized below. The major problems observed in Phnom Penh are caused by insufficient parking space, narrow road width, urban sprawl making inroads into industrial area, and insufficient road maintenance.

The countermeasures being conceived based on identified problems are providing parking space/system, upgrading/improving existing roads, land use planning and enhancing land use control, and improving road maintenance capacity.



Source: PPUTMP Project Team

Figure 2.7-3 Identified Problems of Current Truck Transport

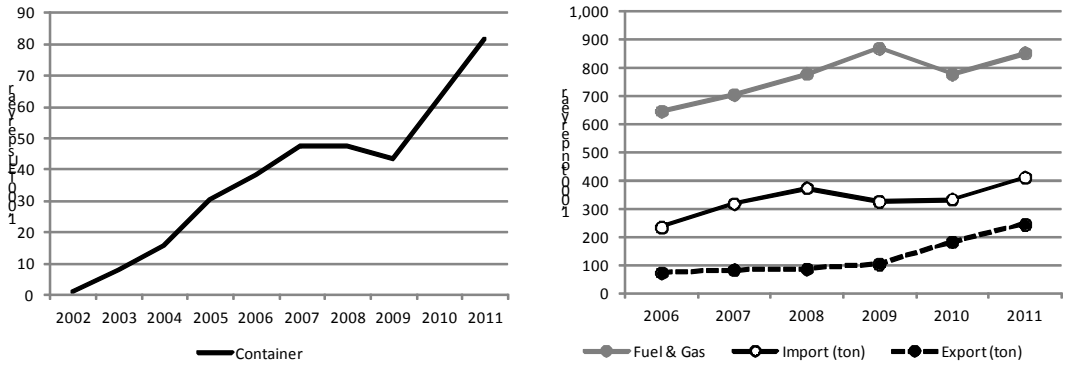
2.7.4 Existing and Planned Facility Relevant to Freight Transport

The existing Phnom Penh Port, PPSEZ and industrial areas on the south of the international airport generate considerable cargo and truck trips. In addition, the new Phnom Penh Port located 30 km downstream from Phnom Penh opened in January 2013, and a railway cargo terminal is planned at the junction of the southern and northern lines. For considering future freight transport in Phnom Penh, these existing and planned facilities relevant to freight transport should be considered.

(1) Phnom Penh Port

Phnom Penh Port is located on the west bank of Mekong River and is used for international and domestic freight and passengers (as of 2012). Vessels of up to 2,000 Dead Weight Tonnage (DWT) are able to use it without difficulty. The length of wharf for cargo ship is 300 m and two mobile cranes are operated for loading/unloading. The capacity of Phnom Penh Port is estimated at up to 100 thousand Twenty-foot Equivalent Units (TEUs) per year and actual handling container was about 82 thousand TEUs in 2011.

In 2011, import and export cargo volumes except fuel and gas at Phnom Penh Port were 411 thousand and 244 thousand tons.



Source: Phnom Penh Autonomous Port (PPAP)

Figure 2.7-4 Cargo Volume at Phnom Penh Port

The new Phnom Penh Port in Kien Svay, 30 km downstream from the city center along NR1, has been opened since January 2013. The port has an area of 12 ha and has two berths for up to 5,000 DWT. As shown in the table below, the expected capacity of the new port is 120 thousand TEUs in initial stage (phase 1) and it will be expanded to 500 thousand TEUs after 2015.

Table 2.7-1 Schedule of New Phnom Penh Port Expansion

	Expansion	Schedule
Phase 1	Capacity of 120,000 TEUs/year	operated since 2012
Phase 2	CY expansion to 300,000 TEUs/year	by 2015
Phase 3	CY expansion to 500,000 TEUs/year	after 2015

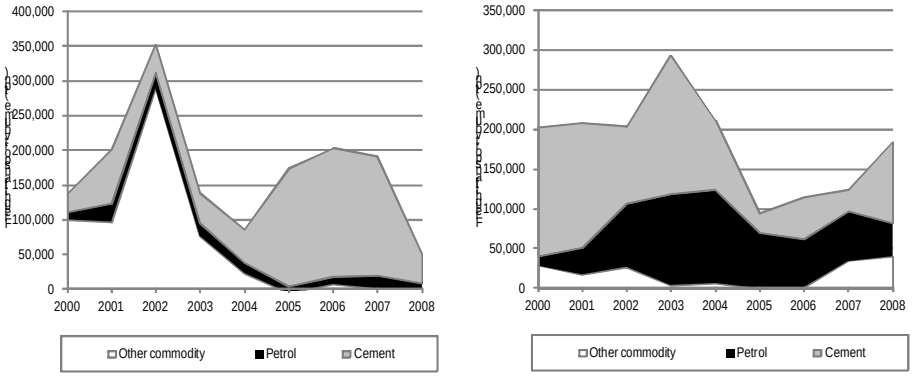
Source: Phnom Penh Autonomous Port (PPAP)

According to PPAP, future handling cargo at the existing and new Phnom Penh Port after 2015 is considered as follows:

- Some dry bulk cargo such as cassava and rice for Vietnam is shipped from the existing port, and some construction materials and container cargo are also handled at the existing port.
- Some domestic agricultural products from Kampong Cham to Phnom Penh are expected to shift from truck transport to inland water transport and landed at the existing Phnom Penh Port.
- Almost all container cargo and dry bulk along Mekong River will be handled at the New Phnom Penh Port.
- Thus, the New Phnom Penh Port in Kien Svay will be the largest international/inter-regional cargo facility in Phnom Penh and surrounding areas, generating container cargo more than 5 times that of the existing Phnom Penh Port.
- Shipped/received cargo at New Phnom Penh Port is mainly relevant to Vietnam, East Asia and North America via Vietnam.

(2) Rail Freight

Freight transport by railway in Cambodia was dominated by cement and petrol as shown in the following figure. However, freight transport volume by railway has decreased since 2002 - 2003. It is supposed that the major reasons of decline of railway freight transport are the competition with road transport and insufficient level of service of railway transport.



Source: Transportation Infrastructure Sector Study in Cambodia (2010, JICA)

Figure 2.7-5 Freight Transport Volume by Railway (left: Northern Line, right: Southern Line)

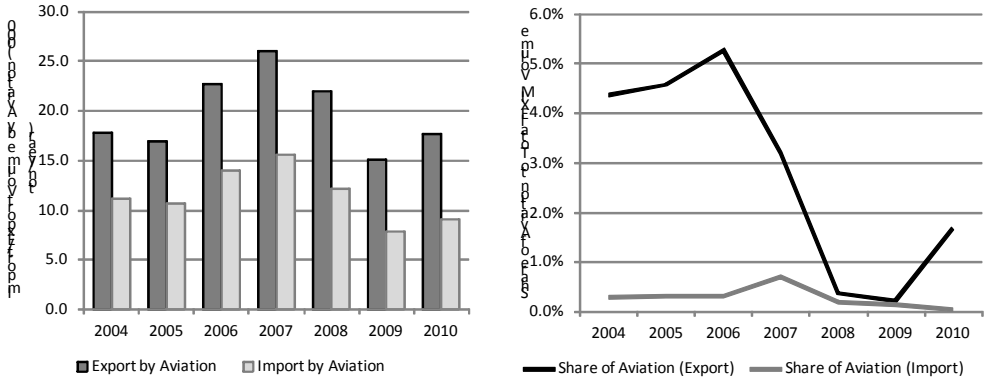
In 2009, the Government of Cambodia concluded 30 years of concession agreement with the Toll Royal Railways (TRR), a joint venture between Australia's Toll Group and local conglomerate Royal Group, to rehabilitate the entire railway network and improve its operation. For the rehabilitation of railway infrastructure and improvement of railway operation, and construction of the 48 km missing link between Poipet and Sisophon and of the new inter-modal freight terminal on the outskirts of Phnom Penh, the Asian Development Bank (ADB) and the Australian Agency for International Development (AusAID) agreed to fund 140 million USD. The targets of service revel of rehabilitation are (i) to upgrade the north line to 20 tons of freight at a maximum speed of 50 km/h and (ii) to upgrade the south line to 15 tons of freight at a maximum speed of 50 km/h.

The rehabilitation work has started since 2009 and all railway operation was suspended until 2010. In 2010, the rehabilitation work between Phnom Penh and Touk Meas (118 km) was completed and freight train is currently operating once or twice a week to carry cement from Kampot to Phnom Penh. The rehabilitation of the whole south line between Sihanoukville to Phnom Penh was completed in 2010. At the north line, the railway section between Phnom Penh and where the north and south lines diverge (32 km from Phnom Penh) has been completed and some railway service has been provided since 2011.

In October 2012, TRR signed a freight logistics agreement with the Siam Concrete Group (SCG) and the United Logistics and Distribution (ULD). As of December 2012, cement and salt are transported by railway from Touk Meas and Kampot to Phnom Penh, respectively. In the future, the south line is expected to transport container cargo, cement and construction materials, petroleum and oil from Sihanoukville or Kampot to Phnom Penh.

(3) Air cargo

In Cambodia, three international airports, namely, Phnom Penh, Siem Reap and Sihanoukville international airports are operated. However, Siem Reap International Airport is mainly used for tourists and Sihanoukville International Airport is used only for domestic scheduled flights at present. Thus, current international air freight in Cambodia is dominated by Phnom Penh International Airport. The following figure shows the cargo volume handled at these three international airports in Cambodia and the share of air export/import (EXIM) volume in Cambodia. EXIM volume by air was decreased in 2007 – 2009 by the economic recession, and the share of air cargo to total EXIM volume was also decreased below 2% of total export volume in Cambodia in 2010.



Source: General Department of Customs and Excise of Cambodia, Statistical Yearbook of Cambodia 2011

Figure 2.7-6 International Cargo by Air

As shown in the following table, on the other hand, domestic air freight is negligibly small.

Table 2.7-2 Domestic Cargo by Air

Year	Total (ton)	Outgoing (ton)	Incoming (ton)
2004	11.8	10.7	1.1
2005	6.5	6.2	0.2
2006	9.1	4.4	4.7
2007	39.9	16.9	23.0
2008	12.4	3.6	8.8
2009	12.4	3.6	8.8
2010	0.0	-	0.0

Source: Statistical Yearbook of Cambodia 2011

In October 2012, it was announced that a new airport is being planned to accommodate the increasing number of foreign tourists and it will be located in Kampong Chhunang Province, about 90 km from Phnom Penh along NR5. The new airport is planned to open in 2025 to 2030.

(4) Dry Port, Special Economic Zone (SEZ), Industrial Park

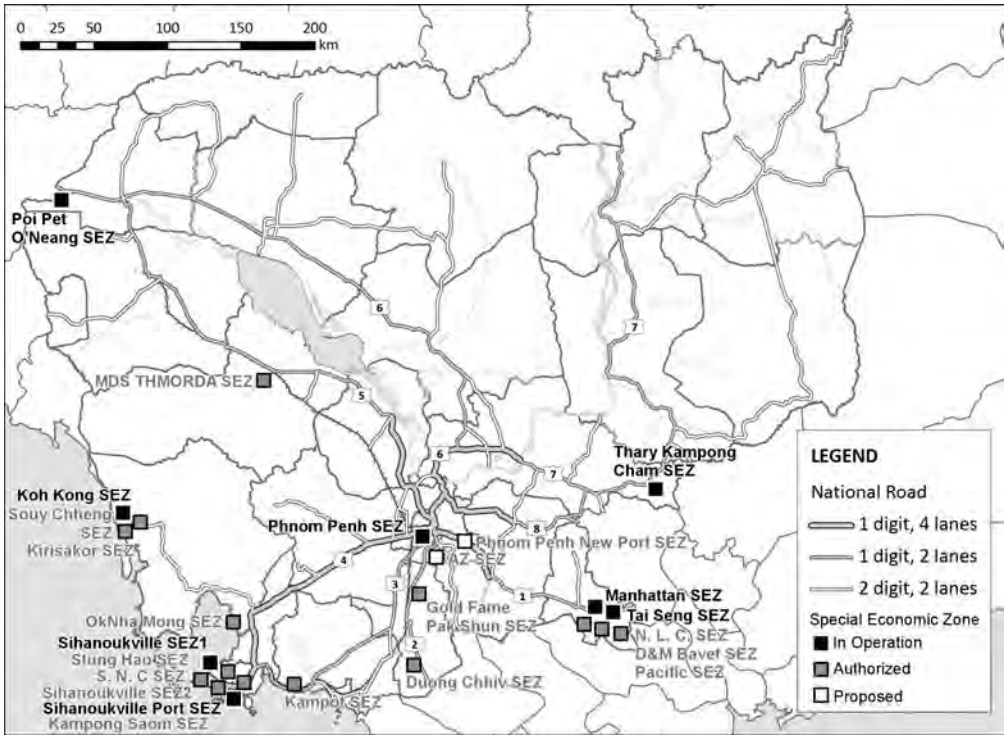
In the study area, PPSEZ, nine dry ports and two industrial parks are located along NR4 and Chaom Chau Road. Especially, SEZ which generates heavy truck traffic is a scheme to attract foreign investment by giving an incentive such as tax treatment due to vitalize regional economy and domestic labor market. As of 2012, eight SEZs are in operation and fourteen SEZs have been authorized in Cambodia. Furthermore, two SEZs are proposed by JICA study and private sector. Most of the SEZs locate in the vicinity of borders of Thailand and Vietnam, or near to international gateways such as Sihanoukville Port or Phnom Penh Port.

Table 2.7-3 List of Special Economic Zones in Cambodia

Location (Province)	Name of SEZ	Land area (ha)	Project Status	Investor (No. of Companies)
Kandal	PPSEZ	350	In Operation	26
	Goldfame Pak Shun SEZ	80	In Operation	3
	Phnom Penh New Port SEZ	250	Plan (proposed by JICA)	None
Takeo	Doung Chhiv Phnom Den SEZ	79	Under Construction	None
	AZ SEZ	177	Plan (proposed by Private Sector)	None
Koh Kong	Neang Kok Koh Kong SEZ	335	In Operation	2
	Suoy Chheng SEZ	100	No Activities	None
	Oknha Mong SEZ	100	No Activities	None

	Kirisakor Koh Kong SEZ	1,750	No Activities	None
Sihanoukville	Sihanoukville SEZ 2	1,688	In Operation	18
	Sihanoukville SEZ 1	178	Under Construction	(2)
	Sihanoukville Port SEZ	70	Under Construction	None
	S.N.C SEZ	150	No Activities	None
	Stung Hao SEZ	196	No Activities	None
	Kampong Saom SEZ	255	No Activities	None
Kampot	Kampot SEZ	145	Under Construction	None
Banteay Meanchey	Poi Pet O'Neang SEZ	467	In Operation	1
Pursat	MDS THMORDA SEZ	2,265	No Activities	None
Sray Rieng	Manhattan SEZ	157	In Operation	18
	Tai Seng Bavet SEZ	99	In Operation	11
	P (SEZ) I C	107	Under Construction	None
	N.L.C. SEZ	105	No Activities	None
	D&M Bavet SEZ	118	No Activities	None
Kampong Cham	Thary Kampong Cham SEZ	142	In Operation	1

Source: Summarized by PPUTMP Project Team based on information of Council for the Development of Cambodia.



Source: PPUTMP Project Team

Figure 2.7-7 Special Economic Zones in Cambodia

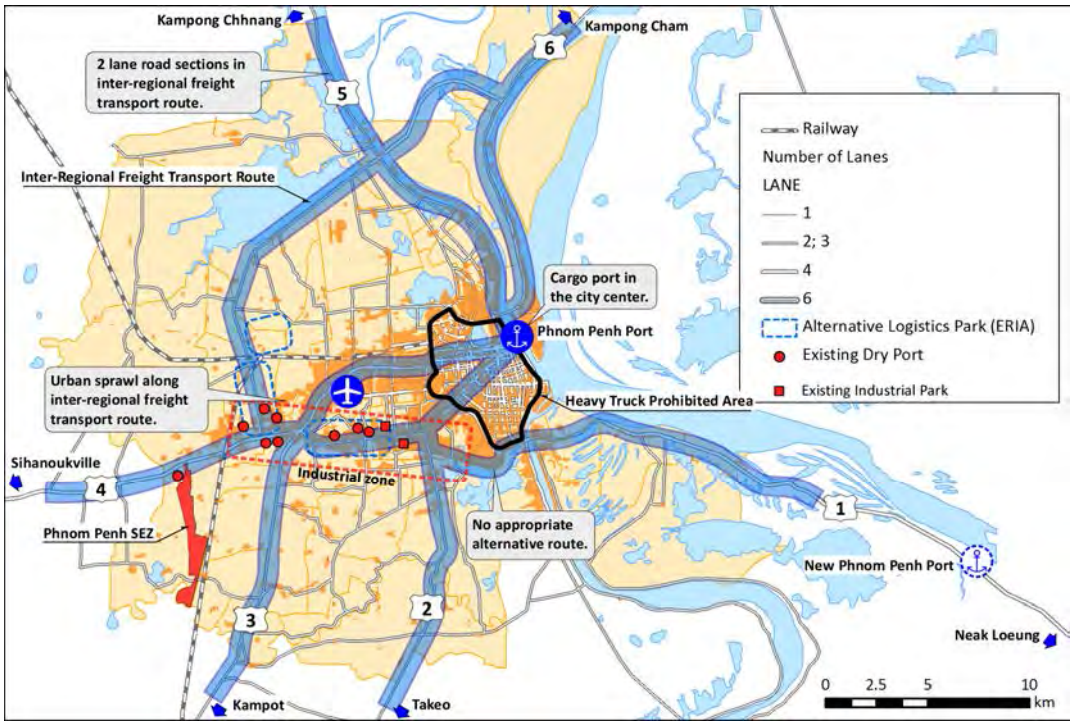
A dry port is an inland facility which performs some port functions such as customs clearance and is also a facility for vanning/devanning to reduce empty container transport and time for EXIM procedures. Along NR4 and Chaom Chau Road, seven of nine existing dry ports are operated in the study area.

In "The Study on Construction and Operation Business on Inland Container Depot in the Second East-West Economic Corridor (2010", by the Economic Research Institute for the Association of South-East Asian Nations (ASEAN) and East Asia), Phnom Penh Logistics Park involving Phnom Penh International Dry Port (PIDP) is proposed. The proposed PIDP is expected to handle 371 thousand TEUs in 2015 and 633 thousand TEUs in 2025, and its required area is 198 thousand m^2.

(5) Problems and Issues of Inter-Regional/Intermodal Cargo Facilities

Identified and expected problem of existing and planned cargo facility are summarized below,

- The existing Phnom Penh Port in the city center will be used after 2015 as cargo port. In general, as a cargo facility generates heavy truck traffic, it should be located outside the urbanized area.
- There are no appropriate alternative routes in parallel with Chaom Chau Road to connect between NR4 and NR1 across the Bassac River. This road is one of the largest heavy truck traffic sections in the study area, therefore, there should be an alternative road connecting NR4 and NR1.
- Existing cargo facilities such as dry ports and industrial parks along Chaom Chau Road are becoming part of the urbanized area because of urban sprawl. In general, an industrial area including cargo facilities should be apart from the urbanized area such as a residential / commercial area to avoid a mixed traffic of truck and daily traffic.
- The number of lanes of some roads corresponding to the inter-regional freight transport route such as RR-II, Chaom Chau Road, NR2 and NR3 is basically 2 lanes. The sections of roads for the inter-regional freight transport route should be able to accommodate the volume of heavy trucks.



Source: PPUTMP Project Team

Figure 2.7-8 Current Freight Transport Network and Problems

2.8 Urban Environment

2.8.1 Natural Environment

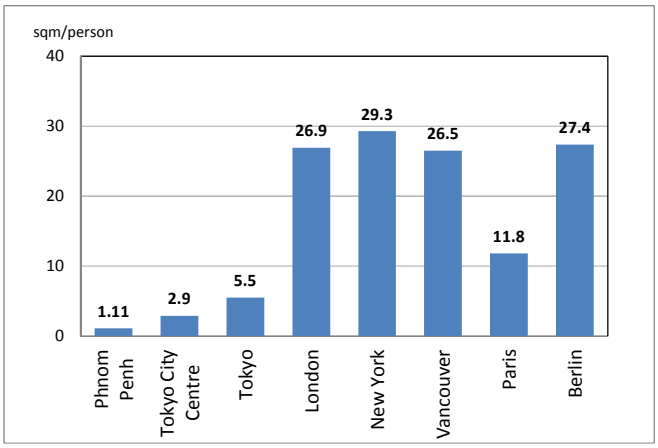
Phnom Penh locates at the corner of the Mekong Delta triangle and faces a meeting point of two large-sized rivers, namely, Tonle Sap River into Mekong River. The land is fertile and relatively flat with an altitude ranging from two to four meters above sea level in general. Phnom Penh enjoys

tropical monsoonal climate and has two major seasons, namely, rainy season from May to October and dry season from November to April. From 2003 and 2010, monthly average rainfall was approximately 180 mm/month in rainy season and 40 mm/month in dry season. It has a rather high temperature and humidity. In the rainy season, the temperature tends to go down around 22 °C because of the wind from Gulf of Thailand, while in the dry season, the highest temperature reaches 40 °C. The average temperature in Phnom Penh was around 29 °C during the year 2003 and 2010.

(1) Conservation and Green Area

There are not any natural and historical conservation areas protected by the Ministry of Environment (MOE) in Phnom Penh. However, in order to conserve diversification of ecosystem, four wetlands are designated close to the study area, namely, Prasat Tuyo Lake, Boeung Veal Samnap, Coeung Prang and Chhok Veal Rench. Besides, Phnom Penh has many historical, religious and cultural buildings such as Wat Phnom, the Royal Palace (and Silver Pagoda) and buildings constructed in the French colonial era. These serve not only as landmarks in Phnom Penh but also as tourist attractions.

Looking at the green spaces in the urban area of Phnom Penh, there are only limited public parks and green areas because Boeung Kak Lake is no longer existing owing to urban development and Tra Bek Lakes are used for lagoon system of wastewater treatment. Urbanization triggered by urban population growth and economic development is likely to decrease open spaces which may be utilized as parks. Based upon the simplified map, the total area of urban green spaces in central area of Phnom Penh including Tra Bek Lakes is around 2.1 km^2. Accordingly, the green area per population in the central area is around 1.1 m^2 per person. This is remarkably small compared to other major cities. Moreover, recently 20 m^2/person[1] is considered as appropriate size of urban green.

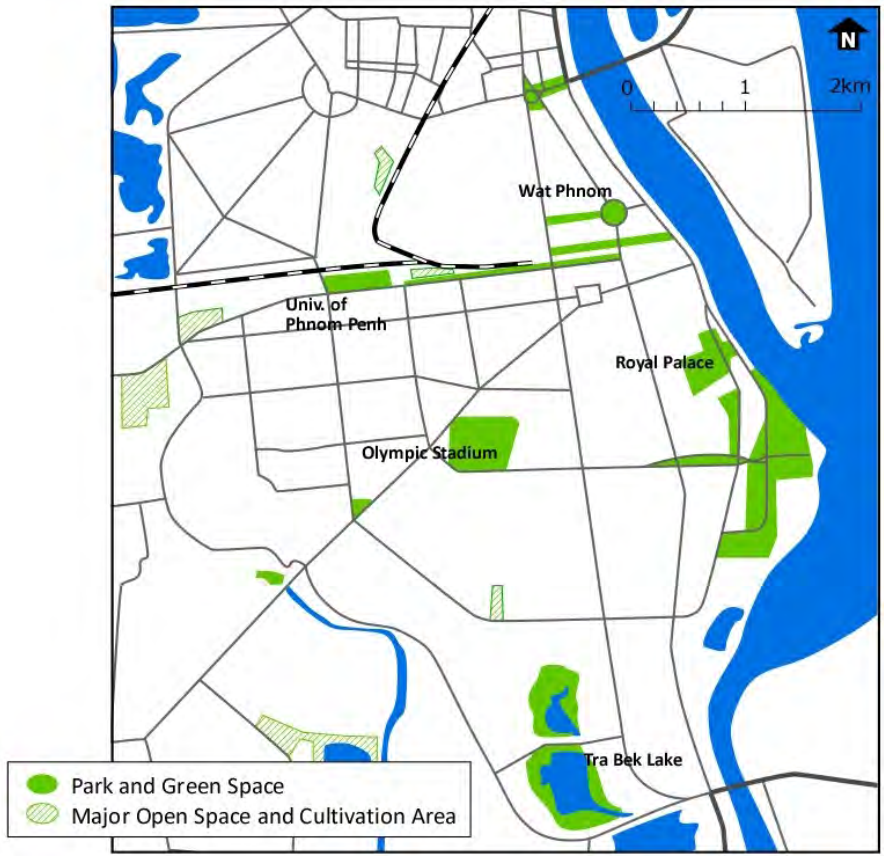


Source: PPUTMP Project Team based upon the data from MLIT, Japan

Figure 2.8-1 Size of Urban Green per Population

Meanwhile, in the suburban area, plenty of green spaces including agricultural land still remained. However, urban sprawl is observed in the suburbs due to rapid urbanization. To avoid decreasing such green area by the sprawl, a practical land use plan and appropriate land development controls are necessary.

[1] Wang, X.J. 2009. Analysis of problems in urban green space system planning in China. Journal of Forestry Research.

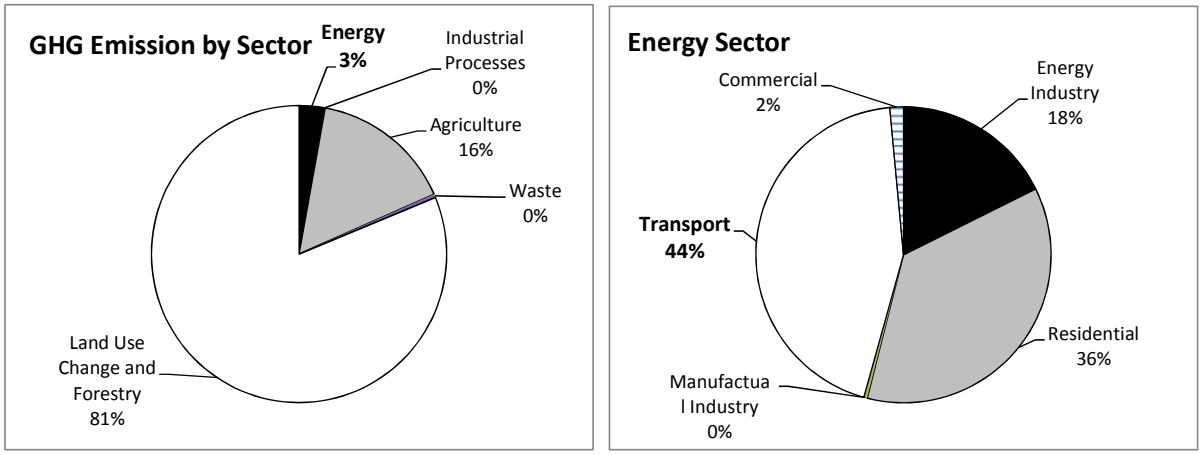


Source: PPUTMP Project Team

Figure 2.8-2 Existing Green Spaces and Public Parks in the Central Area of Phnom Penh

(2) Climate Change

Climate change has become a universal issue in recent years, and Cambodia is also considered one of the most affected countries due to extreme-weather events caused by global warming. In order to cope with climate change, the Cambodian Climate Change Office was established under MOE in 2003 which was predecessor of the Department of Climate Change (DCC). Since then, estimation of the greenhouse gas (GHG) emission in Cambodia has been conducted every five years based on DCC statistical data. Hence, as of 1994, GHG emission from activities related to fuel combustion, namely, energy sector, in entire Cambodia was 1.88 billion tons of carbon dioxide (CO2) of which GHG emission from transport sub-sector accounted for 44%. According to the future projection, in 2020 this figure is expected to reach around 62%.



Source: Cambodia Climate Change Enabling Activity Project (CCCEAP2)

Figure 2.8-3 Projection of GHG Emissions by Sector in Cambodia, 1994

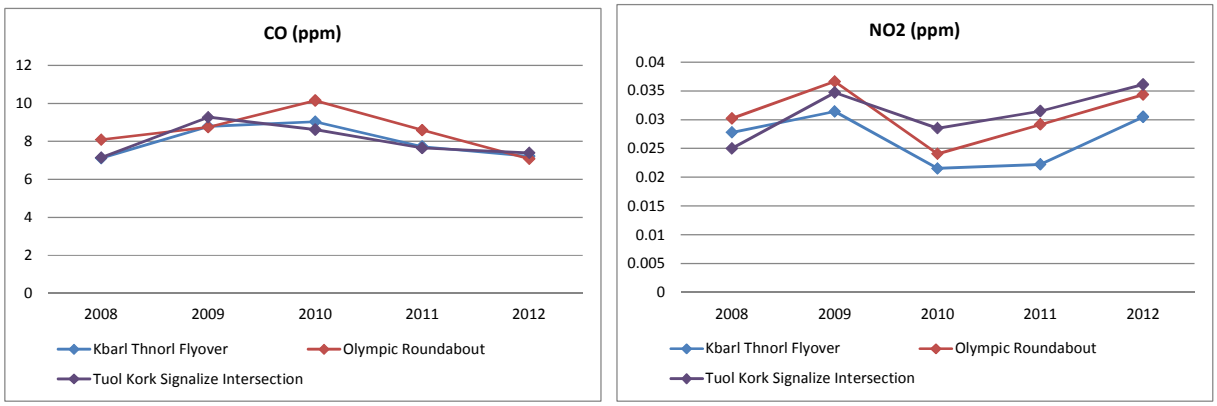
GHG emission data for Phnom Penh is not available since the estimation is only for entire Cambodia, not for individual province. In Phnom Penh, similar to the situation of air quality, it is supposed that increase of vehicles in recent years causes serious impacts on climate change. However, there is not monitoring data for GHG emission including CO2. Moreover, the standard of GHG emission applied for vehicle inspection is not yet prepared in Cambodia. Taking into account the increasing mobilization of urban population, appropriate countermeasures are necessary such as monitoring of CO2 emissions, developing legal systems and introducing public transportation.

2.8.2 Social Environmental Condition

The population in Phnom Penh reached approximately 13.4 million in 2008, which comprised almost one-tenth of the national population. Compared to the data in 1998 and 2008, annual population growth rates in Phnom Penh reached 2.9% in a decade. This indicates a rather higher figure than the national average, which was 1.6% in the same period. Urbanization is triggered by such population growth in Phnom Penh.

(1) Air Quality, Noise and Vibration

Air quality, noise and vibration are regulated by the sub-decree No.42 declared in 2000. This sub-decree indicates actual figure of standards and allowable limits related to air quality and noise including ambient air quality standard, gas emission standard of mobile source, and maximum standard of noise level. In accordance with the sub-decree, air quality monitoring has been carried out regularly at three points in Phnom Penh, namely, Kbal Thnal Flyover, Olympic Roundabout and Tuol Kork Signalized Intersection by MOE since 2000. In this monitoring, data of major air pollutants such as Carbon Monoxide (CO), Sulphur Dioxide (SO2) and Nitrogen Dioxide (NO2) are being collected every month. The results from 2008 to 2012 are shown in following figures. According to the data, CO and NO2 were generally below the standard and large increase could not be identified. SO2 was not detected.



Note: data shows 1 hour average based upon monthly 24hr sampling
Source: MOE, Cambodia

Figure 2.8-4 Monitoring Data of CO and NO2 at 3 Stations from 2008 to 2012

Air quality, noise and vibration are assumed to become worse due to increase in the number of vehicles in Phnom Penh; however, even the monitoring results at the three locations did not show the large growth above. According to the registered vehicle data, the numbers of light and heavy vehicles and motorbikes have been soaring upward in these years. In a decade from 2001, the annual growth rate of light vehicles was 13.9% and that of motorcycles was 11.2%. Thus exhaust gas is increasing in proportion to the number of vehicles. The standard of vehicle emission is enacted; however, the system has room for improvement. The inspection system applies emission tests for meeting of the standard only for new vehicles, not for in-use vehicle.

On the other hand, the increasing and concentrating numbers of factories also contribute to the deterioration of air quality since the economy of Phnom Penh is driven by textile industries. Discharging air pollutants from the factories and gaining heavy vehicle trips for freight are anticipated to increase for the future.

The Department of Environment, Phnom Penh Capital City (DOEPP), has not gathered data on air quality and noise in Phnom Penh so far due to lack of responsible organization for the task and necessary equipment for monitoring. In order to take appropriate countermeasures against the deterioration of air quality and noise, accumulated data and monitoring are vital for analyzing present situation and forecasting.

(2) Water Supply

Water supply and treatment are handled by the Phnom Penh Water Supply Authority (PPWSA). This public cooperation had four water facilities and the total design volume was 430,000 liters/day as of 2012. The service coverage ratio in former Phnom Penh municipality area was 90% in 2010. With an additional 20 districts, according to PPWSA, the coverage ratio might be lower than that. PPWSA aims to achieve 100% coverage ratio by 2020.

Some areas could not have the water supply service due to lack of road access since installation of water pipe is carried out basically under the road. Road development therefore contributes not only to provide mobility but also to improve the service of urban infrastructure including water supply. Furthermore, road construction including development of tunnels and flyovers is likely to closely interact with water pipes laid under roads. Therefore, mutual cooperation between DPWT and PPWSA is important for carrying out urban development efficiently.

(3) Solid Waste Management

Solid waste management is under the jurisdiction of DPWT, Phnom Penh Municipality. In practice, collection of solid waste has been contracted out to a Canadian and Cambodian Joint-Venture called CINTRI except in some specific area[2]. In Phnom Penh there are two disposal facilities: an open dumping site called Stueng Mean Chey Disposal Site and a landfill site called Dorng Kor Landfill Site.

Garbage collection service is available for some areas such as inside the city center, while many other residential areas have not enjoyed the services fully yet causing dumping of solid waste on roadsides and footways, and in rivers and ponds. As a result of inappropriate dumping, sewage pipes are clogged, foul odor is emitted, and flooding occurs. Besides, the environment in the surrounding area of open dumping sites is anticipated to deteriorate due to the odor, fires occurring at the site and contamination of ground water and soil by leachate.

(4) Water Sewage

Wastewater in Phnom Penh is basically collected by sewage pipes and open channels into Tra Bek Lake where it is treated by a lagoon system then discharged into Bassac River. So far there are no wastewater treatment plants for public use in Phnom Penh.

Furthermore, flood triggered by heavy rains is also considered as one of the serious urban problems related to sewage. This issue also influences road traffic and contributes to traffic jams. Shortages of pipe capacity and clogged pipes are considered as main reasons. For coping with this, “The Project for Flood Protection and Drainage Improvement in PPCC” is being implemented at this moment. After completion of the project, the flood mitigation is expected.

In the area near open channels and Tra Bek Lake, the running wastewater is emitting foul odors and attracting mosquitos. The lagoon system has both advantages and disadvantages. The system is reported to have a risk of water pollution problems in case a natural waterbody is used. Further, the system is not very effective at removing heavy metals from wastewater. Taking account of the increased wastewater due to population growth, industrial developments and preservation of biodiversity near Tra Bek Lake, the installation of a wastewater treatment plant needs to be considered in the future.

2.9 Urban Transport-Related Institutions

DPWT holds a position of specialized department under not only Phnom Penh City Hall (PPCH) but also the Ministry of Public Works and Transport (MPWT). DPWT is mainly responsible for the management of all infrastructures such as roads and bridges and other traffic-related structures. In the Progress Report, the roles and responsibilities of DPWT were described in detail.

When PPCH considers the whole system of urban transport for the future, it will be important to share its plans with the Urbanization Division of the Bureau of Urban Affairs (BAU) and other relevant departments that approve and issue permits on urban planning. Looking at the mandates of these organizations, PPCH needs to address existing issues of these organizations supposing the introduction of public transport and the current role of urban transport.

It is recognized that the issues are basically as follows:

[2] The Neighborhood Improvement Program (NIP) area is carried out by the Phnom Penh Waste Management (PPWM) under DPWT.

a) Ineffective policy implementation because of the lack of sharing of the strategy of urban transport;
b) Unclearness of the core organization that will manage positively the urban transport;
c) Lack of a policy to address the problem of traffic jams considering the supply of service to citizens;
d) Insufficient discussion with urban transport enterprises; and
   (Note: Enterprises mean organizations planning to start a business in public transport. Discussion means arrangements for items to be examined.)
e) Insufficient sharing of information and discussion in advance.

Although the above items can be applied not only to Cambodia but also to developed countries, PPCH has to review the recognized issues and current situation immediately and try to find solutions.

As the introduction of bus transport will start soon, PPCH has to make a decision on the division of duties. The duty of the Transport Office of DPWT (indicated at Chapter 13.1.1.), which will be the main player, is very wide; therefore, it is considered that the current number of staff is too small to correspond to all the work items when public transport is introduced. The Transport Office has to grasp fully what it has to do by clarifying the purpose of the introduction of public transport at first and then dividing the process of introduction and management. However, the progress of it will depend on the capacity development of the personnel in the future because currently there are not any personnel backgrounds to indicate a positive management. For this issue, foreign donor assistance is considered a possible solution.

Table 2.9-1 shows a summary of the organization factors and requirements to the realization of public transportation. Although these are for the operation purpose (to earn benefits), the managing parties have to understand that these items have a close relationship with their duties.

Table 2.9-1 Organizational Factors and Requirements for Public Transport

	Factor	Point of Discussion
"Hard" Aspects	Strategy	・Decision on the basic principle ・Setting the plan of business and its review
	Structure	・Examination of solutions to problems and operational issues in systematic way ・Selection and evaluation of enterprises for operation in a systematic way
	System/Institution	・Implementation of business evaluation and setting indicators of the evaluation ・Subsidy ・Guidelines of public transport
"Soft" Aspects	Shared Value	・Consistency with the upper level plan ・Clarification of business ideal ・Decision on input (subsidy)
	Style	・Announcement to citizens ・Positive concern by the transport operator
	Personnel	・Recruitment and bringing on board key persons ・Recruitment and bringing on board the coordinators among organizations concerned
	Skill	・Accumulation of knowledge and know-how on the management of public transport ・Implementation of 3rd country training

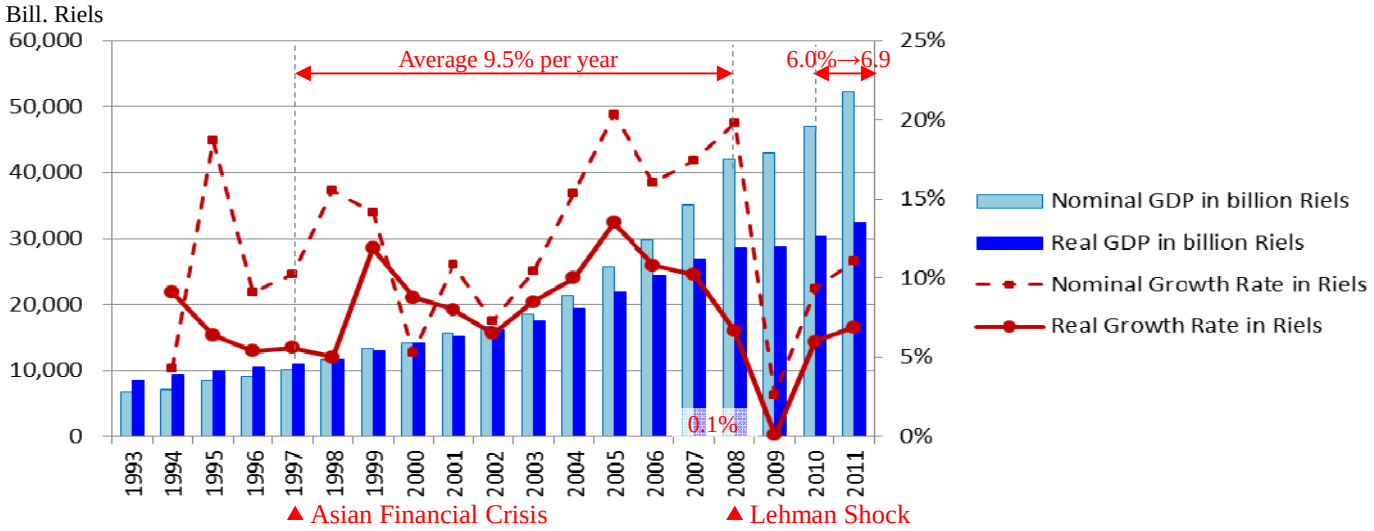
Source: PPUTMP Project Team

3 SOCIO-ECONOMIC FRAMEWORK

3.1 Economic Framework

3.1.1 Trend of Economic Data in Cambodia

The Cambodian economy grew at an average rate of 9.5% per year over a 10-year period from 1998 (the year after the Asian financial crisis) to 2008 (the year of Lehman Shock). In 2009, the Cambodian economy grew no more than 0.1%, then steadily recovered to record a 6.0% growth in 2010 and 6.9% in 2011. This economic trend is shown in Figure 3.1-1 below.



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Nominal GDP in billion Riels	6,813	7,105	8,434	9,202	10,145	11,720	13,376	14,083	15,617	16,756	18,508	21,343	25,693	29,809	35,042	41,968	43,057	47,048	52,254
Nominal Growth Rate in Riels		4.3%	18.7%	9.1%	10.3%	15.5%	14.1%	5.3%	10.9%	7.3%	10.5%	15.3%	20.4%	16.0%	17.4%	19.8%	2.6%	9.3%	11.1%
Real GDP in billion Riels	8,521	9,297	9,896	10,431	11,018	11,570	12,947	14,083	15,215	16,210	17,589	19,351	21,956	24,334	26,870	28,668	28,692	30,406	32,511
Real Growth Rate in Riels		9.1%	6.4%	5.4%	5.6%	5.0%	11.9%	8.8%	8.0%	6.5%	8.5%	10.0%	13.5%	10.8%	10.2%	6.7%	0.1%	6.0%	6.9%
Nominal GDP in million USD	2,480	2,765	3,419	3,486	3,392	3,106	3,507	3,649	3,980	4,273	4,656	5,315	6,278	7,265	8,631	10,337	10,400	11,634	12,874
Real GDP in million USD	3,102	3,617	4,011	3,951	3,684	3,066	3,395	3,649	3,877	4,134	4,425	4,819	5,365	5,931	6,618	7,061	6,931	7,519	8,010
Nominal Per Capita GDP in USD	229	248	297	295	281	253	281	288	309	326	349	392	454	513	575	760	753	830	909
Official Exchange rate(Riels/US$)	2,747	2,570	2,467	2,640	2,991	3,774	3,814	3,859	3,924	3,921	3,975	4,016	4,092	4,103	4,075	4060	4157	4191	4053

Note: GDP= Gross Domestic Product
Source: 1993-2006= Statistical Yearbook of Cambodia 2008
: 2007-2011= Economic and Monetary Statistics Series No.218-19th Year (2011, National Bank of Cambodia)

Figure 3.1-1 Trend of Economic Growth Rate in Cambodia

3.1.2 Projection of Economic Growth by Each Organization

According to the projection by the Cambodian government and the International Monetary Fund (IMF), the Cambodian economy is estimated to grow from 6% to 7% annually in the short term and finally settling to grow at around 7% in the long term.

Table 3.1-1 Economic Growth Rate Assumptions by Cambodian Government and IMF

	2012	2013	2014	2015	2016	2021	2031	Long term
Rectangular Strategy	-	-	-	-	-	-	-	around7%
NSDP Update 2009-2013	6.5%	6.5%	-	-	-	-	-	-
IMF Country Report No.12/46	6.5%	6.4%	6.8%	7.4%	7.4%	7.6%	7.8%	-

Source: Rectangular Strategy for Growth, Employment, Equity and Efficiency Phase II (2008)
: National Strategic Development Plan (NSDP) Update 2009-2013 (2010)
: IMF Country Report No.12/46, Cambodia 2011 Article IV Consultation (2012, IMF)

3.1.3 Economic Framework of the Study Area

There is not enough data related to Gross Regional Domestic Product (GRDP) of Phnom Penh Capital City (PPCC); therefore, the rate of economic growth of Cambodia is used as the rate of economic growth of Phnom Penh.

Referring to the Rectangular Strategy, NSDP Update 2009-2013 and IMF Country Report, the rate of economic growth of Cambodia is established as follows.

Table 3.1-2 Economic Framework

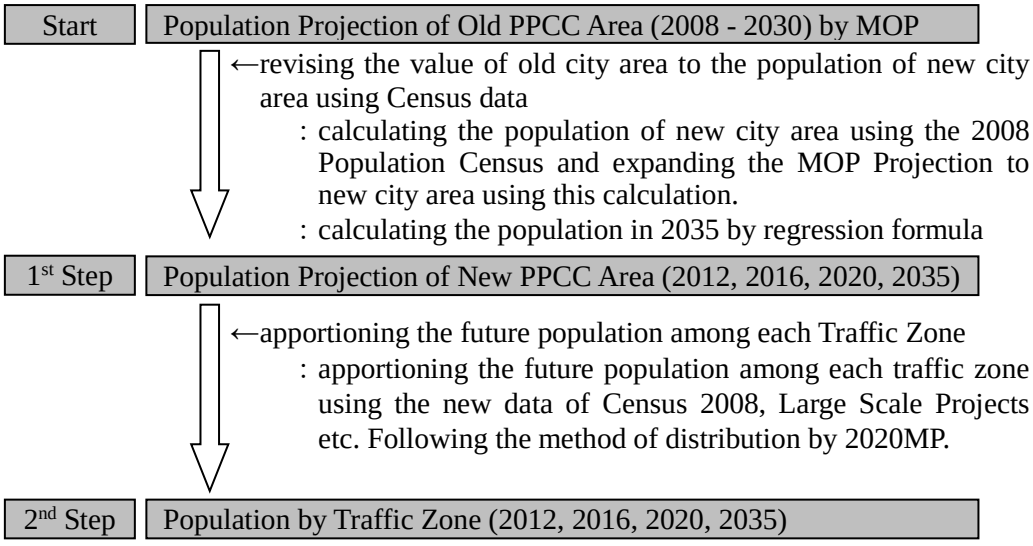
	2008	2012p	2016p	2020p	2035p
Real GDP Growth Rate (%)	6.7%	6.5%	7.5%	7.5%	7.5%

Source: PPUTMP Project Team

3.2 Population

The future population of Phnom Penh in 2016, 2020 and 2035 is estimated based on the population projection of the Ministry of Planning (MOP) in 2011. However, MOP's population projection is a projection of old city area; therefore, the population projection of new city area is estimated using the results of Census 2008.

The population by traffic zone is set based on the data of Census 1998, Census 2008, Phnom Penh Urban Planning Master Plan 2020 (2020MP), etc.



Source: PPUTMP Project Team

Figure 3.2-1 Procedure in Population Estimation

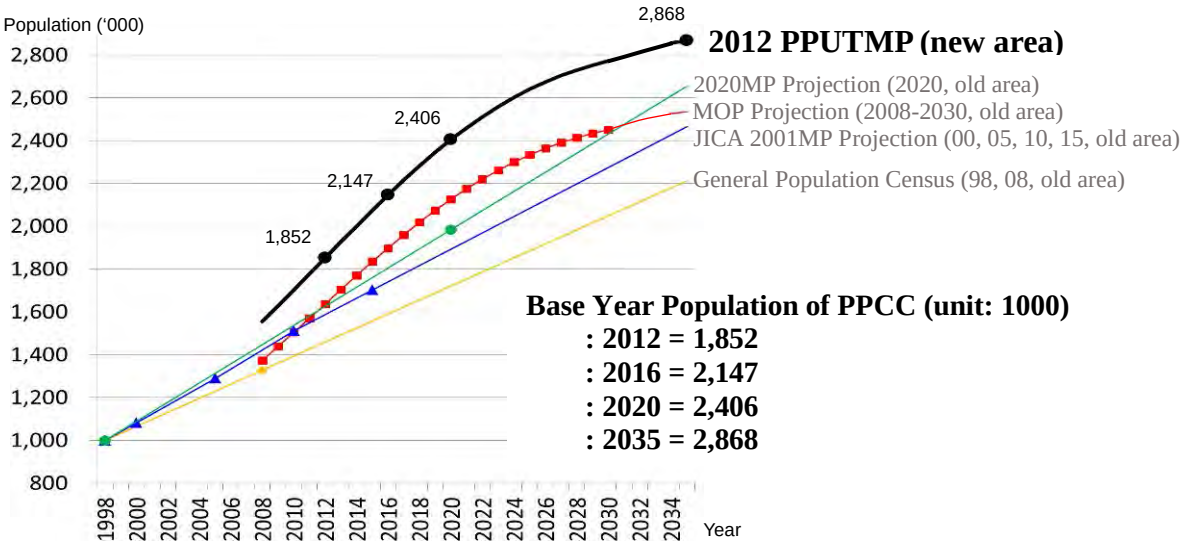
3.2.1 Population of Phnom Penh

The project's base year (2012) population of PPCC was set at 1.85 and that of the target year 2035 was set at 2.87 million.

Table 3.2-1 Population Projection of Target Year (Unit: '000)

	1998	2008	2012p	2016p	2020p	2035p
Phnom Penh (new area)	1,133.4	1,501.7	1,852.2	2,147.4	2,405.5	2,867.6
Phnom Penh (old area)	999.8	1,327.6	1,637.5	1,898.0	2,126.6	2,535.1
Cambodia	11,437.7	13,395.7	14,741.4	15,626.4	16,505.2	19,166.6

Source: PPUTMP Project Team



Note: JICA 2001MP= Urban Transport Master Plan in 2001
Source: PPUTMP Project Team

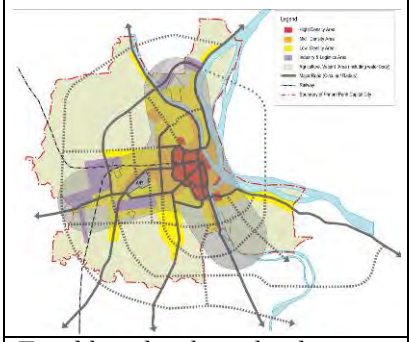
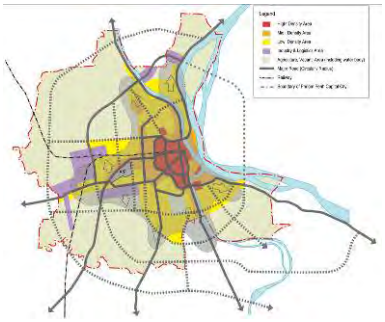
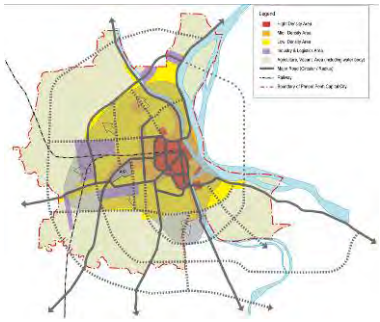
Figure 3.2-2 Population Change Estimate by this Project, Census, Related Projects, etc.

3.2.2 Breakdown into Traffic Zones

(1) Urban Structure and Population Allocation

Population allocation is set based on Alternative 3, which was supported the most at the Stakeholder Meeting on September 6, 2012. Moreover, population allocation of Alternative 1, which is based on present trend as a base case without the project, was also done.

Table 3.2-2 Three Urban Structure Plans Indicated at the Stakeholder Workshop on September 6, 2012

Alt1: Trend-base Case	Alt2: Private-oriented Case	Alt3: Public-private collaboration Case
		
Trend-based urban development: present trend plan : population concentrates along the east and west trunk road	Multi-core based on the private large urban development projects: development project for the radial direction : population concentrates along roads	Multi-core with guided urbanization to northwest direction in suburban area: development project by roads radiating in all directions : developmental type of 2020MP

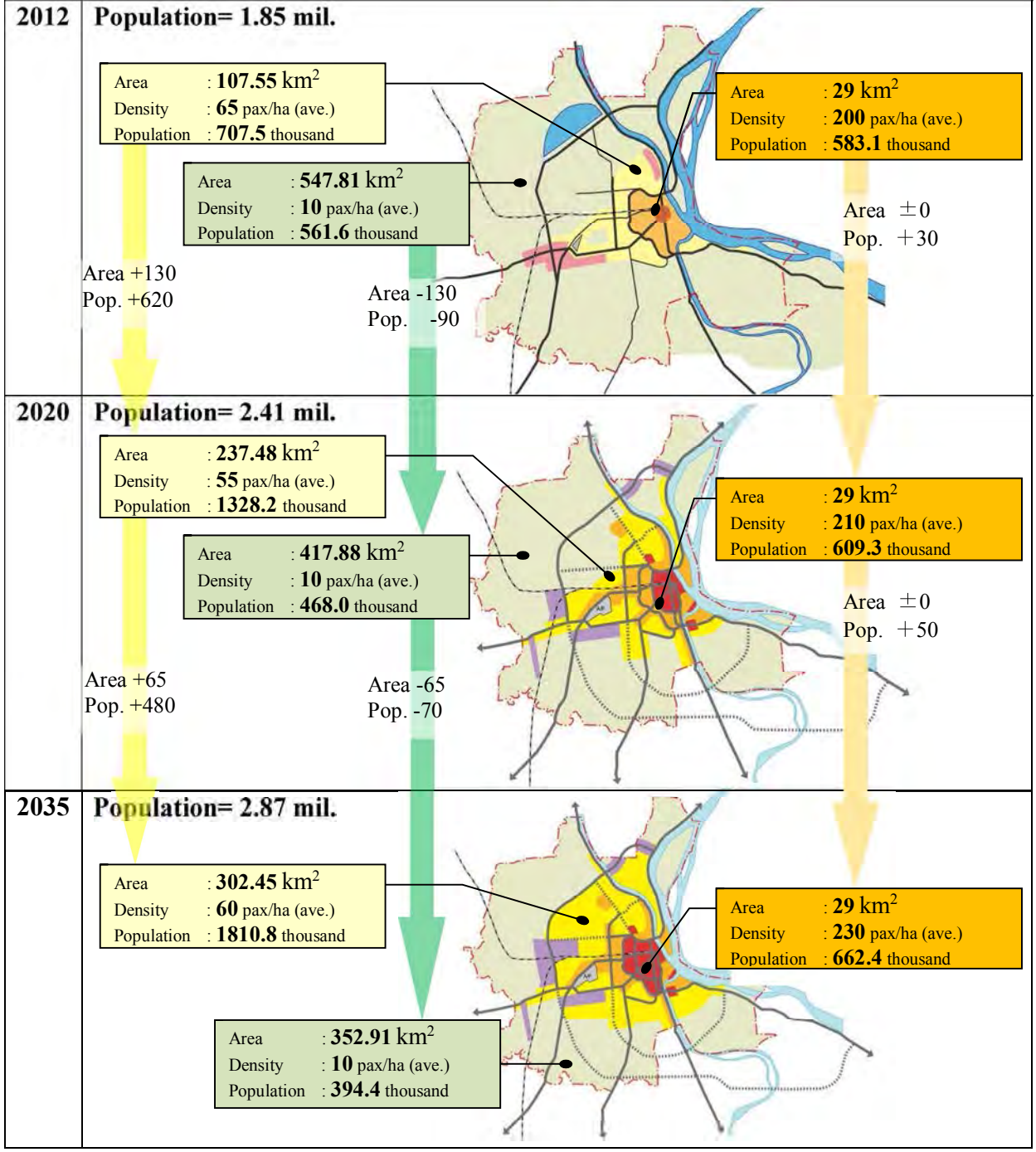
Source: PPUTMP Project Team

(2) The Outline of Population Allocation Based on Alternative 3

The population of the Inner Urban Area is estimated to increase by almost 80 thousand from 2012 to 2035. Meanwhile, over the same period, the area of the Outer Urban Area and its population is estimated to increase by 195 km^2 and 170 thousand, respectively. In the same way, the agricultural area is estimated to decrease by 195 km^2, and its population, by 170 thousand.

Table 3.2-3 Way of Thinking about Future Urban Structure and Population Allocation

Year	Urban Structure and Population
2012	**Population= 1.85 mil.**
2020	**Population= 2.41 mil.**
2035	**Population= 2.87 mil.**



Note: The Inner Urban Area (orange) corresponds to Zones 1-44. The Outer Urban Area of 2012 (yellow) corresponds to 9-63, 69-71, 73, 74, 77, 80, 83, 84, 92, 93, the area of 2020 - 46, 56, 59-65, 69-71, 73-75, 77, 79-89, 92-95 and 2035 year - 6, 53, 56-65, 69-71, 73-77, 79-89, 92-95. The rest is Agricultural Area (green).

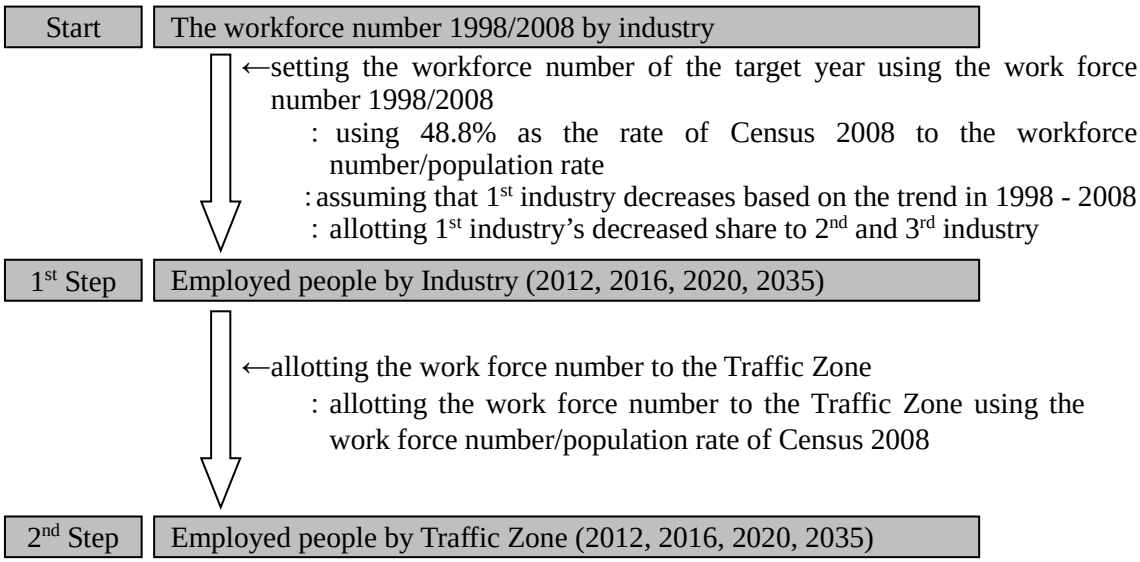
Source: PPUTMP Project Team

3.3 Employment

3.3.1 Employment

(1) Estimation Procedure

The workforce of PPCC is set following the procedure show below, using the population statistical results of the 1998 Population Census, the 2008 Population Census and this project.



Source: PPUTMP Project Team

Figure 3.3-1 The Procedure of the Workforce Estimation

(2) The Workforce of Target Year

The workforce by industry is set as follows.

Table 3.3-1 Employment Projection in PPCC by Industry (Unit: '000)

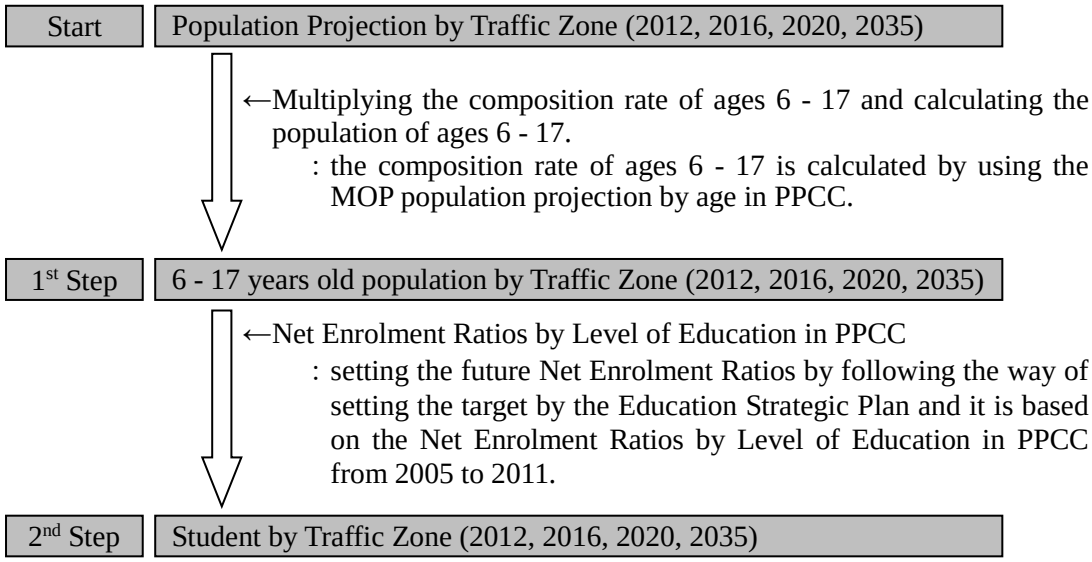
	2008		2012		2016		2020		2035		Difference
	No.	%	No.	%	No.	%	No.	%	No.	%	2035-2012
Population	1,502	100.0%	1,852	100.0%	2,147	100.0%	2,406	100.0%	2,868	100.0%	+1016
Workforce	733	100.0%	900	100.0%	1,050	100.0%	1,170	100.0%	1,400	100.0%	+500
Primary	70	9.5%	65	7.2%	60	5.8%	55	4.8%	40	2.7%	-25
Secondary	240	32.7%	300	33.5%	360	34.1%	400	34.4%	490	35.2%	+190
Tertiary	423	57.7%	535	59.2%	630	60.1%	715	60.8%	870	62.0%	+335

Source: PPUTMP Project Team

3.4 School Enrolment

3.4.1 Procedure to Estimate Number of Students

The number of students in PPCC is determined by calculating the population belonging to the group aged 6 - 17 years using the population by traffic zone above and multiplying it by the net enrolment ratios by level of education.



Source: PPUTMP Project Team

Figure 3.4-1 Procedure to Estimate Number of Students at School Locations

3.4.2 Net Enrolment Ratios by Level of Education in PPCC

The net enrolment ratios by level of education in PPCC from 2005 to 2011 are shown as follows.

Table 3.4-1 Net Enrolment Ratios by Level of Education in PPCC

	Number				Net Enrollment Ratio		
	Primary	L.Sec	U.Sec	Total	Primary	L.Sec	U.Sec
2004/2005	148,784	63,123	38,849	250,756	91.6%	68.1%	27.1%
2005/2006	140,550	64,715	44,895	250,160	93.7%	65.6%	37.0%
2006/2007	131,126	63,617	46,812	241,555	91.3%	68.7%	52.9%
2007/2008	118,980	60,834	51,088	230,902	93.2%	63.5%	52.4%
2008/2009	113,979	53,605	50,736	218,320	87.8%	55.1%	40.1%
2009/2010	113,320	49,639	50,501	213,460	91.8%	50.0%	46.8%
2010/2011	133,113	52,404	48,942	234,459	92.4%	52.4%	39.2%

Note: L.Sec= Lower Secondary School, U.Sec= Upper Secondary School
Source: Education Statistics and Indicators (Ministry of Education, Youth and Sport)

3.4.3 Number of Students at Target Year 2035

The number of students of the target year 2035 is set as follows.

Table 3.4-2 Number of Students at Target Year

	2012	2016	2020	2035
Number	188,600	251,800	368,900	435,500

Source: PPUTMP Project Team

4 URBAN VISION AND URBAN STRUCTURE

4.1 Urban Vision

4.1.1 Review of Urban Vision in Previous Plans

(1) Urban Master Plan in 2020 (by France)

The "White Book on Development and Planning of PPCC" (hereinafter referred to as "2020MP") is an urban master plan for Phnom Penh Capital City (PPCC) prepared by a French consultant team under French assistance that was completed in 2009. It delineates land use plan and urban facilities plan targeting the year 2020. The Plan is approved by PPCC and currently in the approval process in the Cambodian Parliament. Accordingly, it is necessary to acknowledge the plan if anyone is considering further urban planning and urban transport planning for PPCC.

1) Vision and Mission

The plan first of all recognizes continuous urban growth in terms of population increase and economic growth and underscores the importance of supplying more jobs and formal employment in PPCC. To this end, the plan emphasizes the following urban functions of PPCC to be enhanced:

- Intersection of Southern Corridor and Growth Corridor
- Political and administrative center
- Service center within a radius of 100 km
- Receiver of foreign investment

PPCC is required to accommodate the urban functions above by appropriately providing space for economic activities, residential areas and efficient transport, so that the plan takes into account the following 8 strategies:

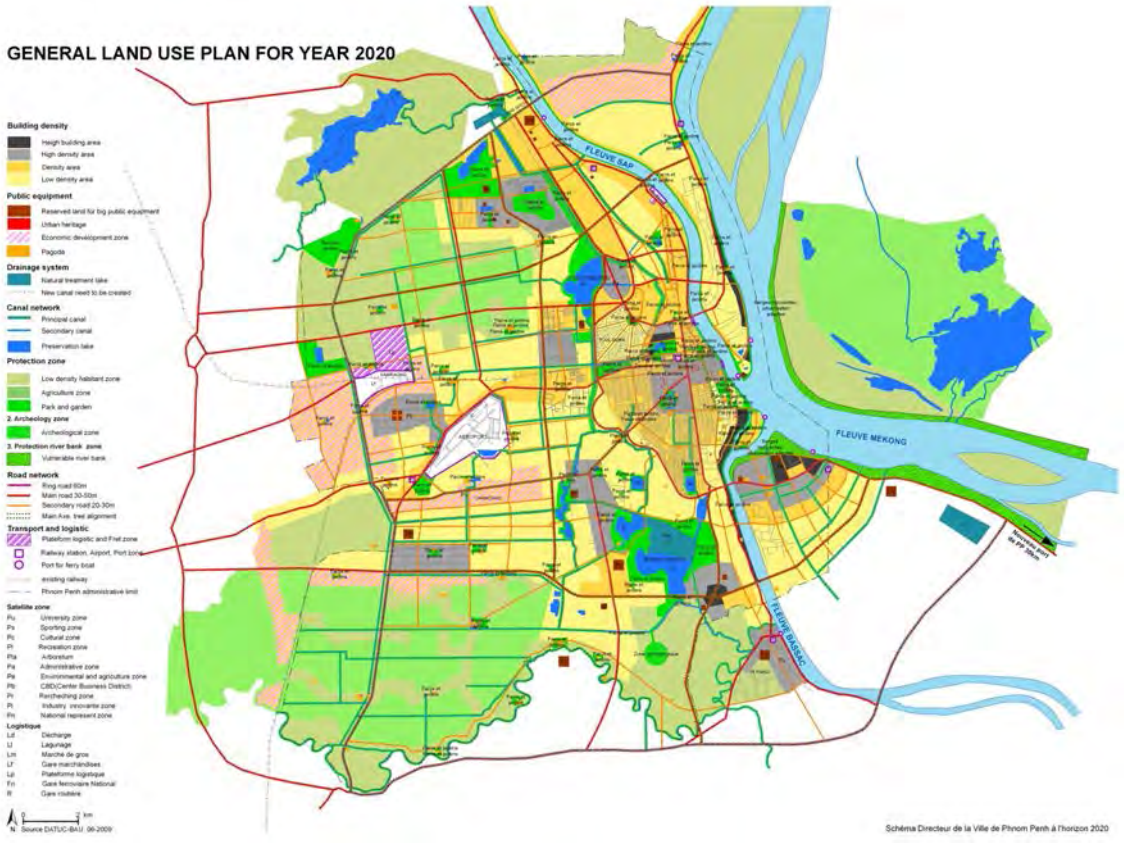
- Pre-condition of existing infrastructure development projects/plan
- Determination of public space border
- Preparation of places for economic development and population growth
- Expansion of city boundary to cover a radius of 20 km
- Coordination of development partner
- Strengthening of green space
- Definition of function and development type by area
- Strengthening of economic capacity

2) Framework

The plan applies 1.98 million persons in 2020 as a population framework of urban planning.

3) Land Use Plan

Land use plan in the "White Book on Development and Planning of PPCC" is shown in Figure 4.1-1.



Source: White Book on Development and Planning of PPCC, 2009

Figure 4.1-1 Land Use Plan 2020 (by France)

4) Current Status of the 2020 Urban Master Plan

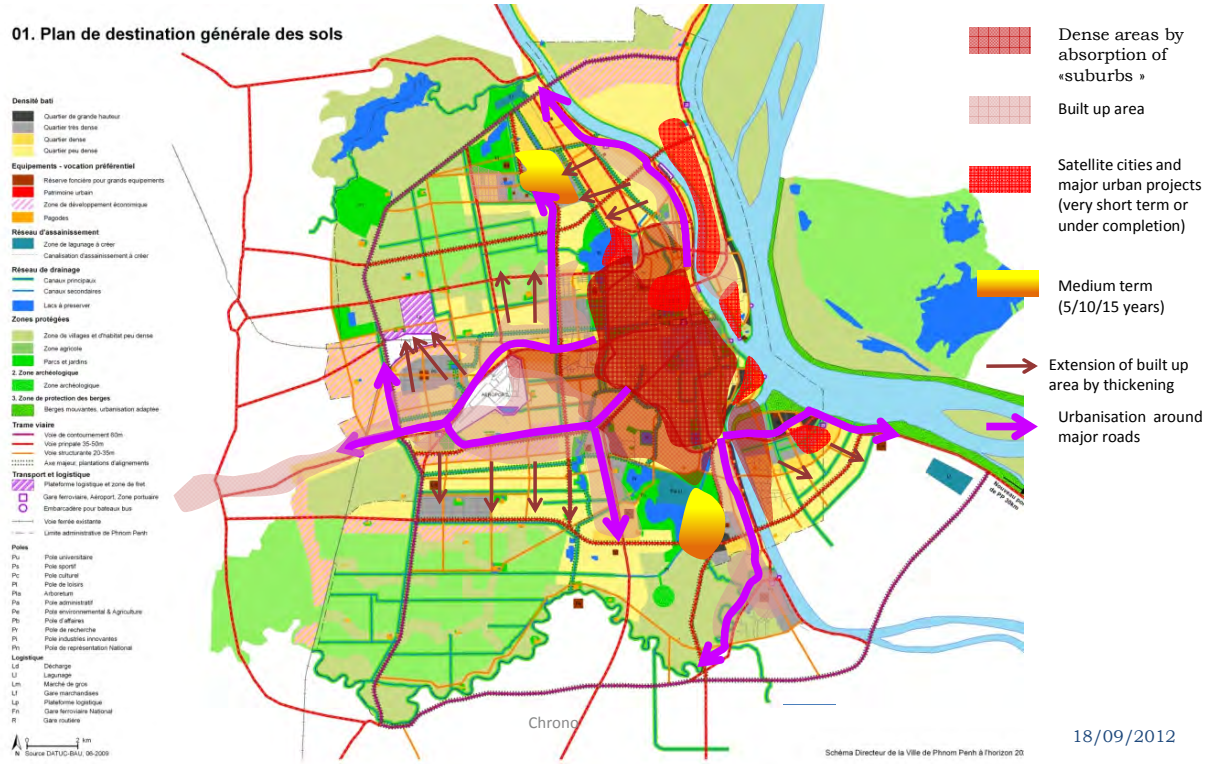
The current master plan formulated by the French is already at the national Parliament for approval, as mentioned in the previous section, and it seems it will be approved even though the question of when cannot be foreseen at this moment. Accordingly, it is necessary for the future urban structure in 2035 to keep consistency with the current urban master plan.

(2) Urban Plan in Tramway Feasibility Study (F/S) by SYSTRA (2012)

F/S on introducing tram system to PPCC, namely, "FASEP Phnom Penh N°914, Phase 1 – Diagnosis and Perspective", was carried out by SYSTRA, a French consultant firm, in 2012. The study aims at introducing tram system as public transport into PPCC. The study is ongoing but many discussions are currently disclosed in public. One of them is review of land use plan in the 2020 Master Plan.

Figure 4.1-2 is a tentative land use plan in 2030 developed by SYSTRA, which is a precondition of traffic modeling and demand forecast of the tram system.

This plan follows (with no change) the land use plan of the French Plan described above even 10 years later, but seems to assume more actual urbanized areas in the west direction following current urban expansion.



Source: FASEP Phnom Penh N°914, Phase 1 – Diagnosis and Perspective Edition 1, Mar 2012, SYSTRA

Figure 4.1-2 Land Use Plan 2030 (by SYSTRA)

4.1.2 Urban Vision

PPCC is required to keep the position of a driving force in economic development of Cambodia by utilizing its strategic location relative to three cross points, namely, 1) historical river cross point (Mekong/Tonle Sap/Tonle Basac), 2) Asian Highway cross point (Indochina Southern Corridor/Central Corridor/Growth Corridor) and 3) regional industrial cross point (Sihanoukville Port/New Phnom Penh Port/Kampong Chhnang New Airport/Agro-industrial Zone in the Mekong River East Bank). With fully utilizing such advantageous location, PPCC should accumulate more economic activities. On the other hand, PPCC is the largest city in Cambodia with a population of 1.8 million. Urbanization is rapidly proceeding; urban area is expanded; high-rise buildings are constructed in downtown; and traffic congestion often observed due to increase of cars and motorcycles, depending upon population increase and economic growth. The severity of these problems would rise with growth of economic activities and population, so that PPCC is increasingly required to solve/ mitigate such urban problems.

Many stakeholders who attended the workshop shared the above understanding. They pointed out the necessity of improving the physical functions of PPCC to be a more sophisticated city with high mobility and IT to lead Cambodia to be a more modern society. Another aspect they wanted to focus on was environmental friendliness. Finally, the PPUTMP Project Team confirms the following vision which reflects the opinions of the stakeholders:

Phnom Penh – Smart, Mid-Mekong Capital City - is the Economic Hub and Center of Population in Cambodia, People Friendly and Environment Friendly

This urban vision of PPCC implies the following basic framework of future urban development as well as urban structure:

PHNOM PENH CAPITAL CITY IN 2035

Source: PPUTMP Project Team

Figure 4.1-3 Phnom Penh Capital City in 2035

Young Population creates Vital Urban Activities

The population of PPCC in 2035 is about 2.9 million, and 70% belongs to the working-age group from 15 to 64 years old. And 15% of Cambodia's population is concentrated in PPCC.

There are still many social immigrants from other provinces even though the population growth rate has slowed down a little. This is the basic factor for the vitalization of the city.

High Mobility and Convenience to the Transportation Poor

There are several modal choices prepared for all citizens but basic mobility is walking comfortably based on well-provided pedestrian spaces such as sidewalks. Many people decide to shift from private mode to public transport as more priority is put on the development of pedestrian spaces and public transport.

Proximity of Living and Working Place: New Urban Living and Flexible Working Style

Following the compact-city development in PPCC, not only high and active commercial and business functions but also comfortable urban residences are provided. Therefore, a new type of residential place and workplace not far from each other has emerged in the city.

Workers in the suburban area have alternatives of working places as these are not only found in the city center but also in suburban districts where commercial, business, and industrial sub-centers, among other economic opportunities, are developed.

Rich and Comfortable Urban Environment and Eco-friendly Suburban Environment

A rich and comfortable urban environment with parks and street trees along sidewalks is provided in the city center.

In the suburban area, agricultural land is appropriately managed even though the total area of cultivated land has decreased a little. This supports part of the city's economic production and maintains the urban environment.

A variety of ecosystems are brought up based on the agricultural land, remaining ponds/lakes and natural greenery.

4.2 Future Urban Structure

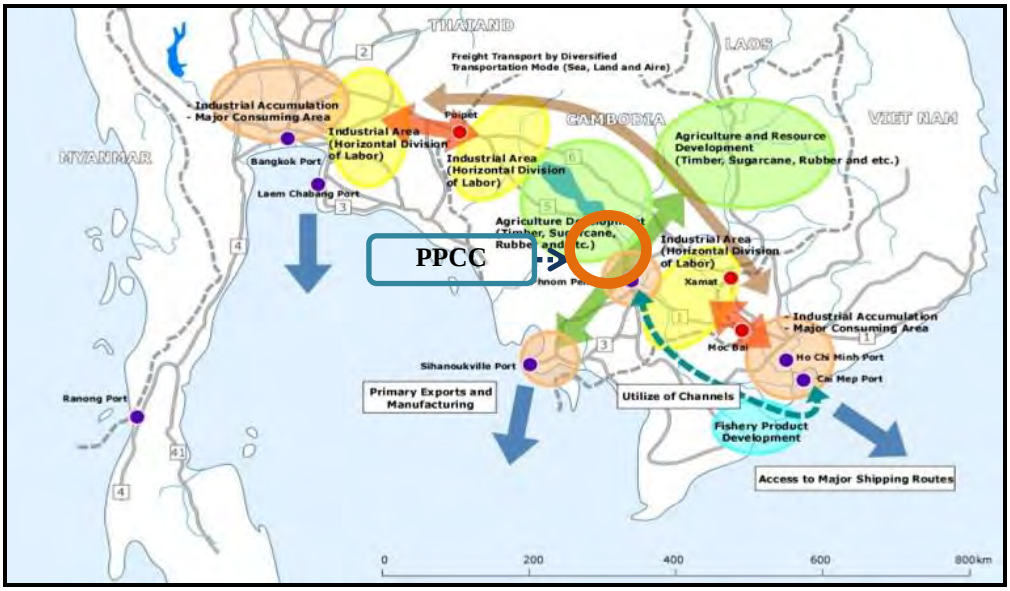
Based on the analysis of current urbanization as well as review of existing urban plans of PPCC, the PPUTMP Project Team shall prepare PPCC's future urban structure for 2020 and 2035.

4.2.1 Future Regional Context of PPCC

(1) Regional Context

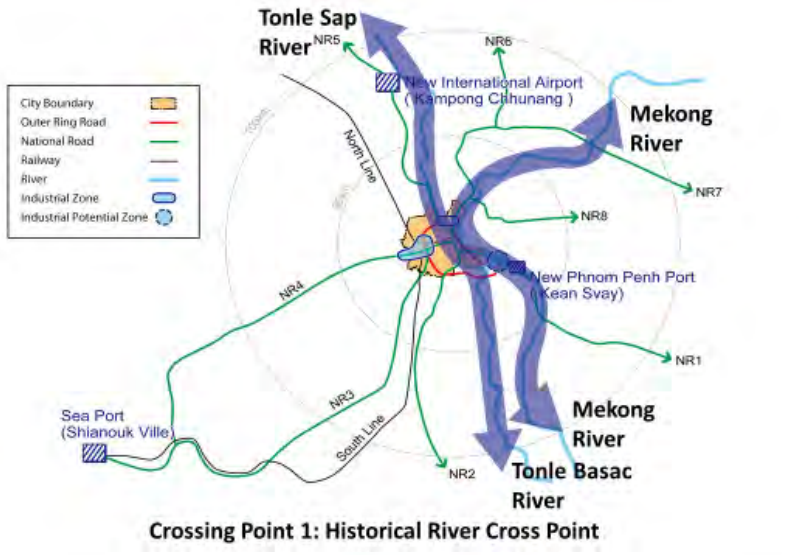
PPCC is the capital of Cambodia and the economic and administrative center of Cambodia too. Its population accounts for about 10% of the country's population. PPCC is a driving force in the economic development of Cambodia, so that its economic function shall be maintained or rather enhanced to lead the economic development of Cambodia. From the regional point of view, PPCC is located strategically at three cross points, namely, 1) historical river cross point (Mekong/Tonle Sap/Tonle Basac), 2) Asian Highway cross point (Indochina Southern Corridor/Central Corridor/Growth Corridor) and 3) regional industrial cross point (Sihanouk Ville Port/New Phnom Penh Port/Kampong Chhnang New Airport/Agro-industrial Zone in the Mekong River East Bank) as shown in Figure 4.2-1 and 4.2-2. With fully utilizing such advantageous location, PPCC should accumulate more activities related to:

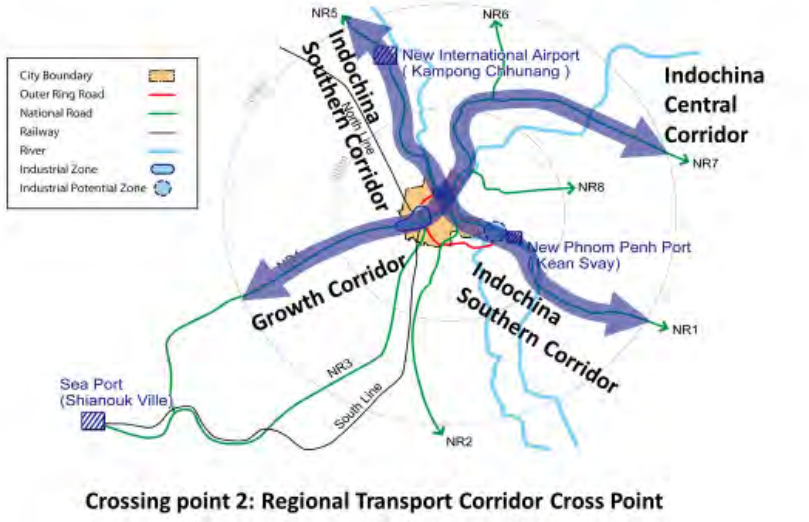
- Manufacturing under foreign direct investment
- Service and trade for 100 km radius area from PPCC
- Administration and public service center

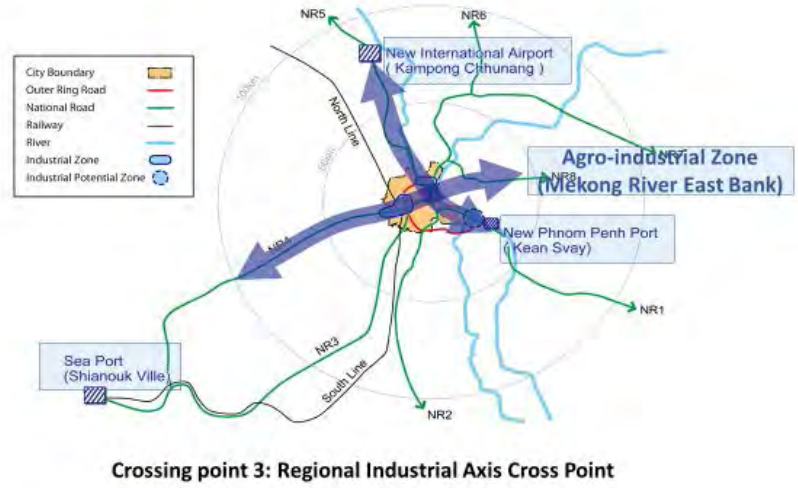


Source: PPUTMP Project Team

Figure 4.2-1 Strategic Location of PPCC







Source: PPUTMP Project Team

Figure 4.2-2 Strategic Three Cross Points

(2) Regional Transport Network

1) Ring Roads

The Ministry of Public Works and Transport (MPWT) of Cambodia has an overall ring road system development plan for PPCC. The ring road system consists of 4 ring roads, namely, Inner Ring Road (IRR), Middle Ring Road (RR-II), Outer Ring Road (RR-III), and Outer-outer Ring Road (RR-IV).

IRR is completed as St.271, which is located in the built-up area of PPCC to perform as inner distributor road. IRR also is a boundary of inner urban area with higher density and of suburban area with middle/low density area. RR-II is relatively newly proposed ring road, which is not seen in any previous studies regarding urban planning and urban transport planning in PPCC like in the JICA or French Study, but its importance is currently recognized. Existing Hanoi Road is designated as a part of RR-II. RR-III is expected to play important roles such as urban fringe area of PPCC, flood protection, bypass of PPCC to avoid merging through-traffic and urban traffic, and industrial road to promote industrial location along the road. RR-IV is also newly proposed ring road. The "JICA Study on Road Network Development Master Plan in 2006" designated that NR51 should be updated as RR-III, which mainly functions as short-cut route connecting Sihanoukville (NR4) with North-eastern region (NR6), and Eastern Region / Vietnam (NR1) with North-western region (NR5 and NR6). RR-III by MPWT is located between NR51 and RR-II, and will be constructed to expand the existing provincial road.

Besides IRR, the other ring roads are not yet completed. RR-II and RR-III are partially completed while RR-IV is still under planning. There are certain donors who are interested in constructing RR-II and RR-III, so that these roads should be considered as a future basic road network in PPCC for the delineation of the urban structure of PPCC.

2) Railway

There are two railway lines in Cambodia, namely, north line and south line and PPCC is a terminal of both railway lines. Due to heavy deterioration of railway lines, a track rehabilitation project is currently under implementation with funding from the Asian Development Bank (ADB).

The railway rehabilitation project targets both north and south lines. For the north line, 34 km of the section from PPCC to Sisophon and 40 km of the section from Sisophon to Poipet are almost completed while some 300 km of the other section has no exact implementation plan due to shortage of budget at this moment. On the other hand, for the south line, 90% of the line is completed and the remaining 10% will be shortly completed.

Railway operation is now privatized and being run by an Australian company. It operates freight trains between PPCC and Kampot once a week; and major good transported is salt. The Australian company used to transport cement between PPCC and Touk Meas, but this service has stopped.

Besides the train operation, the company gets concession to construct and manage an Inland Container Depot (ICD) along the railway lines. ICD is planned to be located at the area bifurcation point of the north and south lines along RR-III. At present, the operation company is in the stage of land acquisition.

Consequently, as railway transport, the south line and ICD should be considered as a future basic road network for the delineation of the urban structure of PPCC.

3) Port

Phnom Penh Port is a river port which has approximately 100 thousand Twenty-foot Equivalent Units (TEUs) per year of capacity. Although current throughput is 60 thousand TEUs per year, Phnom Penh Port will reach full capacity soon due to rapid increase of throughput in accordance with the country's economic growth.

In response to this situation, the Phnom Penh Port Authority has prepared a new port development plan at approximately 20 km south from current port along the Mekong River. On the other hand, there is another plan to utilize an old pier located 5 km north from Phnom Penh Port, which is now under study by Korean assistance.

Since these new port projects are still in the initial stage, there is still a long process to be done such as design, land acquisition, financing plan, management plan and execution. Considering current situation, a new port might not be necessary to consider in the urban structure in 2020, but may be necessary to consider in the urban structure in 2035.

4) Airport

The existing international airport has been gradually enclosed by built-up areas due to rapid urbanization in the west direction giving rise to safety issues and problems with future expansion. There are plans, however, to construct a new international airport at Kampong Chhnang in around the year 2030. After-use of current international airport is not yet clear at this moment.

However, it is noted that the existing international airport offers some advantages as follows.

The airport capacity could be increased if the air traffic control system is improved and both parallel taxiway and high speed exit taxiway are constructed.

a) At the same time, it would be necessary to clear the approach zones of the runway such as maintaining them as greenery.
b) The airport location offers passenger convenience as it is only 7 km away from the city center.

Considering current situation, a new international airport at Kampong Chhnang should be taken into account for the delineation of the urban structure in 2035.

(3) Satellite Cities (new urban area development)

There are several ideas on large urban development outside PPCC such as 1) air city at Kampong Chhnang, 2) new urban area development at the opposite side of PPCC across the Mekong River, and 3) new satellite city at Kandal state. These projects may have large impact on the urban structure of PPCC in terms of size of population and size and quality of economic activities and transport network. However, there is no sufficient information on these projects due to non-availability of exact plans.

Considering current situation, there is no way of considering this in the urban structure of PPCC for both 2020 and 2035.

4.2.2 Preconditions of Urban Planning in PPCC

(1) Population

Table 4.2-1 shows future population of PPCC. As the table shows, the population of PPCC will increase to 2.4 million in 2020 and 2.8 million in 2035. Total employment will increase to 1.2 million in 2020 and to 1.4 million in 2035 in accordance with the population increase. It implies that the urban area should be appropriately provided with residential areas to accommodate the additional population and with working places to accommodate the increase of employment as well.

Table 4.2-1 Population Framework

	2008	2012	2016	2020	2035
Population (unit:1000)	1,502	1,852	2,147	2,406	2,868
Employment (unit:1000)	733	900	1,050	1,170	1,400
Primary	70	65	60	55	40
Secondary	240	300	360	400	490
Tertiary	423	535	630	715	870

Source: PPUTMP Project Team

Population density analysis indicates 100 persons/ha is a current average population density in the built-up area of suburban area and can create good residential environment in the suburban area. With considering this population density as the future average population density, PPCC shall be required 5,540 ha of land to be developed between the years 2020 and 2012, and 4,620 of land to be developed between the years 2020 to 2035.

Table 4.2-2 Required Urban Area Based on Population Projection

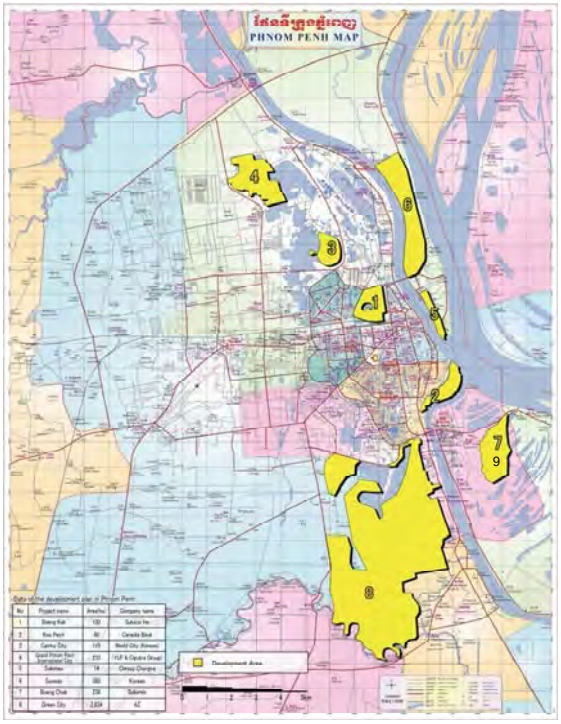
		2012	2020	2035
Population Increase	(thousand persons)		554	462
Urban Area	(km2)	107.7	162.7	208.7
Urban Area Ratio	(%)	15.8	24.0	30.8
Area to be Urban Area	(km2)		55.40	46.20

Source: PPUTMP Project Team

(2) Existing Large Urban Development Projects

PPCC currently has several urban development projects under a favorable economic situation, which are shown in Figure 4.2-3. These urban development projects are very large projects with residential development, and commercial and office development. These projects plan to accommodate large populations, and commercial and office spaces. Progress of the projects is different project by project. Currently, some of them are under construction like Platinum City Project, Diamond City Project, Camko City Project and Grand Phnom Penh Project, while the other projects are still in the planning level like Satellite City Project, Boeung Chuuk Project and Green City Project.

These projects have large impacts on future urban structure. Assuming continuous economic growth in Cambodia in the future, it is natural to suppose that these projects would be basically completed in the long term even though there will be accidental delays due to change of situations in certain occasions.



		Location	Area (ha)	Use	Progress	Project Owner
1	Boueng Kok	Srah Chak in Doun Penh	133	Commercial and Office, Residential (40,000)	Under Construction	Sukaco
2	Diamond City	Tonle Basak in Chamkar Mon	80	Commercial and Office, Residential (5,000)	Under Construction	Canadian Bank
3	Camko City	Phnom Penh Thmei in Saen Sokh	119	Residential (10,000)	On Sales partically and Under Construction	World City
4	Grand Phnom Penh	Khmuonth in Saen Sokh	233	Commercial and Office, Residential (12,000)	On Sales partically and Under Construction	YLP & Ciputra
5	Chrouy Changva	Chrouy Changva in Ruessei Kaev	14	Commercial and Residential	Under Construction	Soximex
6	Satellite City	Preaek Lieb, Preaek Ta Sek in Ruessei Kaev	380	Commercial and Office, Residential (40,000)	Under Planning	OCIC
7	Boeung Chuuk	Nirouth in Mean Chey	238	Residential (2,0000)	Under Planning	Soximex
8	Green City	Chak Angrae Leu, Chak Angrae Kraom in Mean Chey. Dangkao, Cheung Aek, Preaek Kampis in Dangkao	2634	Residential (200,000)	Under Planning	AZ
9	Pratinum City	Nirouth in Mean Chey	80	Residential (6000)	On Sales partically and Under Construction	Borey Peng Huoth

Source: PPUTMP Project Team

Figure 4.2-3 Current Large Urban Development Projects

4.2.3 Urban Structure in 2020

PPCC is required several roles and functions as the capital as well as economic driving force of Cambodia. Urban structure aims at realizing visions and missions discussed in the several meetings of Cambodian side like stakeholders meeting with careful attention on the socio-economic framework and preconditions as well as future regional context around PPCC.

As mentioned in the previous section, there is the 2020 Master Plan, which is under approval process in the Parliament. The structure plan should start to confirm the validity of the 2020 Master Plan from current socio-economic conditions including urbanization, population, etc.

(1) Evaluation of Land Use Plan in 2020MP

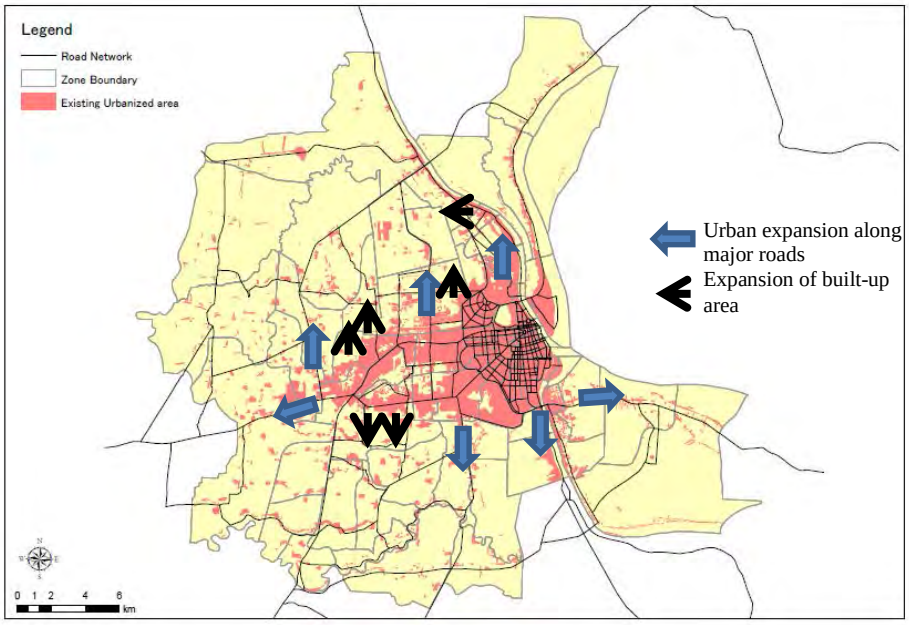
PPCC currently experiences rapid economic growth and population increase. This trend seems to be more accelerated recently, so that the validity of the land use pan in 2020MP is first of all examined from the following point of views:

- Conformity of land use plan with direction of current urbanization
- Conformity of urbanized area with framework
- Relation to urban development projects with land use plan
- Relation to ring roads system with land use plan

1) Conformity of Land Use Plan with Direction of Current Urbanization

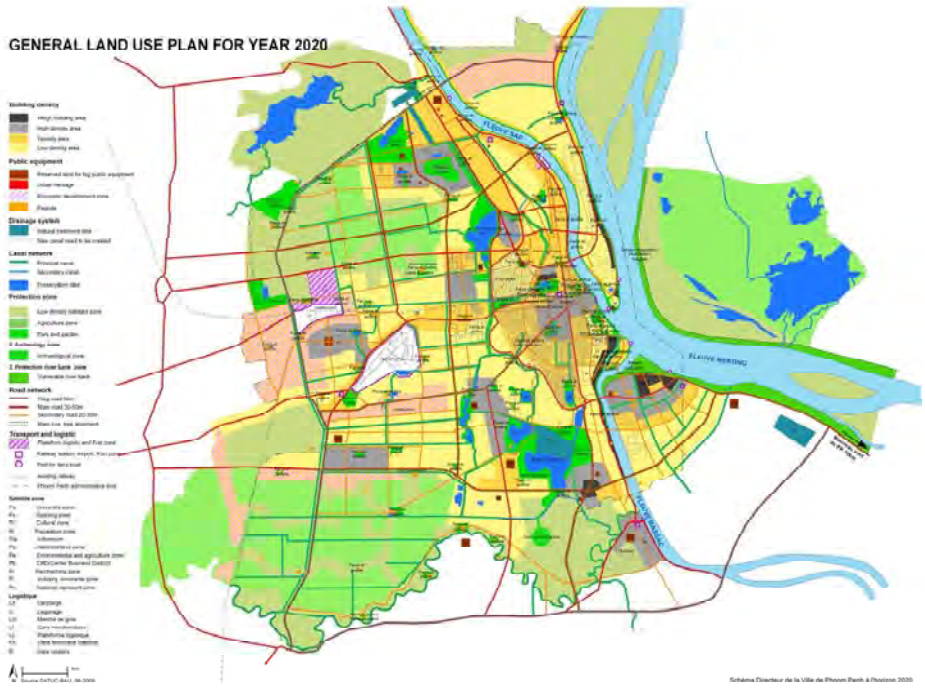
Current urban expansion of PPCC is conceptually indicated in Figure 4.2-4. Based on the analysis made in section 4.1.1, current urban expansion could be understood by dividing it into two movements: One is urban expansion along the major roads. Urbanized area expands toward the west,

north and south directions along NR4, NR5 and NR1, respectively. The other is expansion of built-up areas. The existing urbanized areas expand to the areas behind, in particular, the area in the west direction.

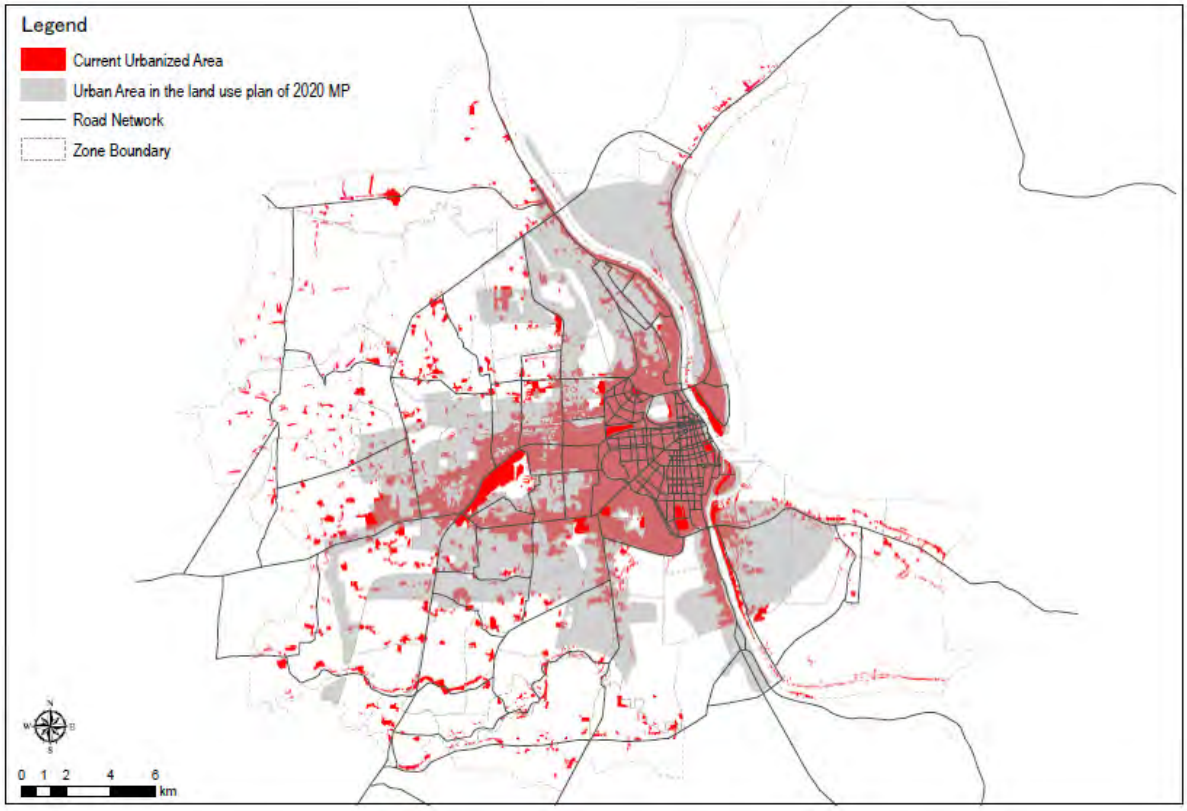


Source: PPUMTP Project Team

Figure 4.2-4 Current Urbanization Directions



(Figure 4.1-1 is re-shown for comparison with above figure.)



Source: PPUTMP Project Team

Figure 4.2-5 Current Urbanized Area and Urban Area in 2020MP

Figure 4.2-5 shows current urbanized are (red color) and the land use plan in the 2020MP (gray color). The land use plan well designates urban areas to be built-up for residential and economic activities in the same direction of current urbanizing areas, i.e., west, north and south directions along the national roads. In particular, the land use plan widely designates the urban area in the west direction to cover the development behind the existing built-up area. It can be, accordingly, concluded that the land use plan is still workable under the current urbanization direction.

2) Conformity of Urbanized Area with Framework

The master plan 2020 by SYSTRA applies a population of 1.98 million as a framework of the plan. Since the previous city boundary is smaller than current city boundary, it is interpreted as about 2.26 million persons with the current boundary. On the other hand, the PPUTMP Project Team makes new population projections based on the new city boundary with latest population data from the Ministry of Planning, which are approximately 2.4 million in 2020 and approximately 2.9 million in 2035. Comparing both population projections, future population re-estimated by the PPUTMP Project Team is a little bit higher than that of the 2020MP.

The 2020MP designates approximately 190 km^2 of land to be developed in the land use plan, which is large enough to accommodate future population in 2020.

Table 4.2-3 Required Urban Area from Framework

			2012	2020	2035
PPUTMP	Population	(thousand persons)	1852	2,406	2,868
	Urban Area	(km2)	107.7	162.7	208.7
2020MP	Population (population estimated with current boundary)	(thousand persons)	---	1,980 (2,260)	---
	Urban Area	(km2)	---	190	---

Source: PPUTMP Project Team

3) Relation of Private Urban Development Projects with Land Use Plan

There are nine large-scale private urban development projects as discussed in section 4.2.2. Some projects have already commenced and some are still in the planning stage, but all projects have obtained official construction permission. Looking into the type of land use in the land use plan by each project location, most of them are located at urban area with high/ medium density except for Grand Phnom Penh and Green City. The areas of the Grand Phnom Penh and the Green City are both designated as "park and garden" area in the land use plan. However, since Grand Phnom Penh is under sales and development, while Green City is still in the planning stage, these areas cannot be park and garden areas.

4) Relation of Ring Roads System with Land Use Plan

The Ministry of Public Works and PPCC currently refined PPCC's ring road system which consists of 4 ring roads, namely, IRR, RR-II, RR-III and RR-IV. The new route concept of the ring road system in PPCC is different than that of the 2020MP. Therefore, coordination is necessary between MPWT's proposal and the 2020MP's.

5) Conclusion

In general, current urbanization and population framework basically keeps conformity with the land use plan in the 2020MP. Although the 2020MP designates the land to be developed as urban land larger than the land required, it is not enough reason to modify the land use plan. However, there are few discrepancies between current land use and land use plan, which are caused by current private urban development projects. Accordingly, there is no need to drastically modify/update the land use plan in the 2020MP at this moment but only minimal changes in the following:

- Ring road system
- Land use at areas of some private urban development projects (Green City, Grand Phnom Penh)

(2) Urban Structure

1) Urban Area

Since the PPUTMP Project Team confirmed that the current urbanization basically meets the land use plan in the 2020MP, the Team has adopted the concept of land use plan in the 2020MP, considering a new population framework. Speaking more concretely, the PPUTMP Project Team follows land use intensity, urban centers and major transport network of the land use plan; however, urbanized areas shall be examined by the Team based on the future population of 2020. In this regard, the Team determined the urbanized area with the following considerations:

- Urban expansion along the road will be a major driving force;
- Private development will provide certain new urban areas; and
- Public sector has little power/ measures in place to guide/ control urbanization until 2020.

Urban expansion constantly continues the following current urbanization directions, which are along major roads, the expansion of built-up areas to the areas behind from road side, and large-scale private urban development (residential complex development) projects.

The total urbanized area will be approximately 160 km^2 in 2020 to accommodate a population of 2.4 million.

2) Land Use and Intensity

Urban development will actively continue in accordance with expansion of investment based on the economic growth and population increase. In the area within IRR, most of the area is densely built-up. Many urban redevelopment projects with high land use intensity currently occur in this area due to higher land prices and no vacant space.

In the area outside IRR, built-up area expands along the major roads and back land of built-up areas along the major roads will be gradually developed with low land use intensity. Some areas like the area along Russian and private development areas will be developed with medium intensity.

The areas along Chaom Chau Road and NR4 currently have accumulation of factories. This situation will continue, thus expanding the areas along NR4 and RR-III following current development.

- Inside IRR: high and medium density mixed land use
- Outside IRR: medium density at private development areas and the area along NR4, the other area, low density
- Industrial areas along Chaom Chau Road, NR4 and RR-III
- Other: Green and farm land, water body, vacant land, etc.

3) Urban Centers

Urban centers will be more clearly formulated with urban redevelopment projects and private development projects, which will generate denser commercial, business and service facilities. On the other hand, the western area around existing airport along Chaom Chau Road, NR4 and RR-III will be a production and logistics center with unique accumulation of factories. Anticipated urban centers with high density areas are:

- Urban Center (Boueng Kok, Monivong, Diamond City)
- 8 Sub-centers (Chbar Ampov, Kandal, Grand Phnom Penh, Camko City)
- Production Center (Chaom Chau, RR-III)

4) Transport Network

PPCC has radial and circular road network, which forms major transport corridors as follows:

Major transport node:

- Phnom Penh International Airport, Phnom Penh Port, New Phnom Penh Port

Major transport corridor:

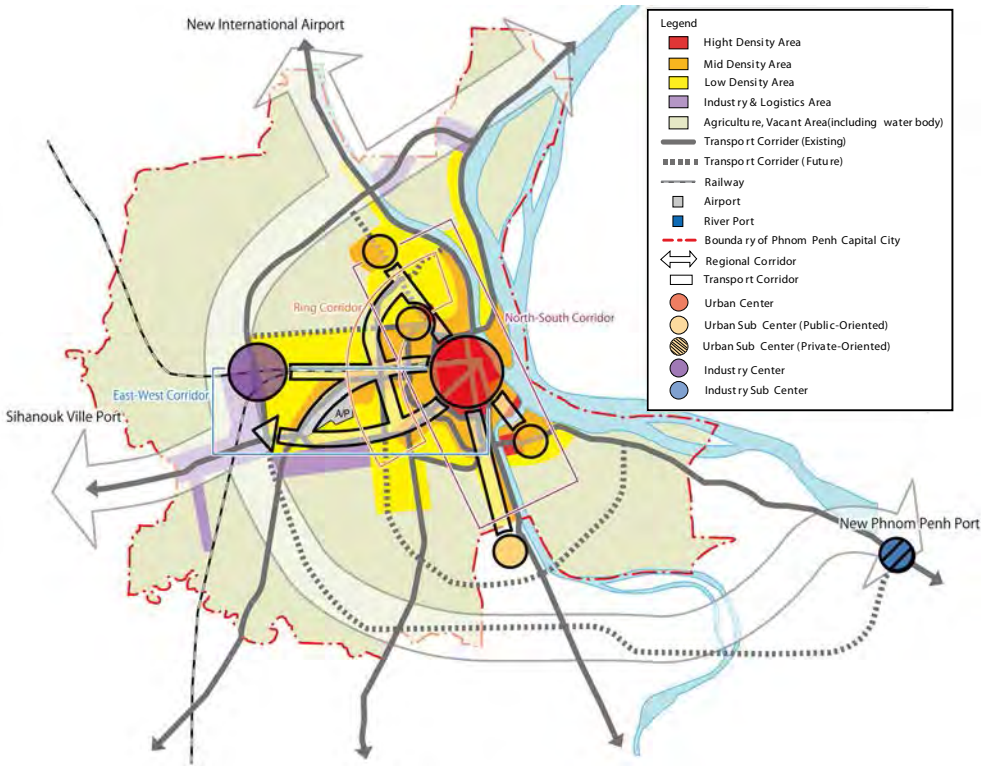
- North-South Transport Corridor including 3 sub-corridors supports the urban institutional,

business and commercial activities
- East-West Transport Corridor including 3 sub-corridors supports the urban industrial and commodity activities
- Ring Transport Corridor (Grand Phnom Penh - Stueng Mean Chey) supports the urban connectivity

Regional corridor:
- Growth Corridor and Indochina Central Corridor: Sihanoukville - NR4 - PPCC - NR6
- Indochina Southern Corridor: NR1 - PPCC - NR5

Mode interchange area:
- Both ends and intersection of major transport corridors

The planned urbanized area in the 2020MP is relatively wider because of the adoption of lower population densities. The planned future urbanized area in this project aims to develop a compact development considering the current urbanization and population density configuration. Therefore, urbanization to southern area in the urban structure is suppressed unlike that in the 2020MP. The abovementioned urban structure is conceptually illustrated in Figure 4.2-6.



Source: PPUTMP Project Team

Figure 4.2-6 Urban Structure in 2020

4.2.4 Urban Structure in 2035

(1) Potential Urban Structure to Accommodate Future Population

1) Urban Area Required in 2035

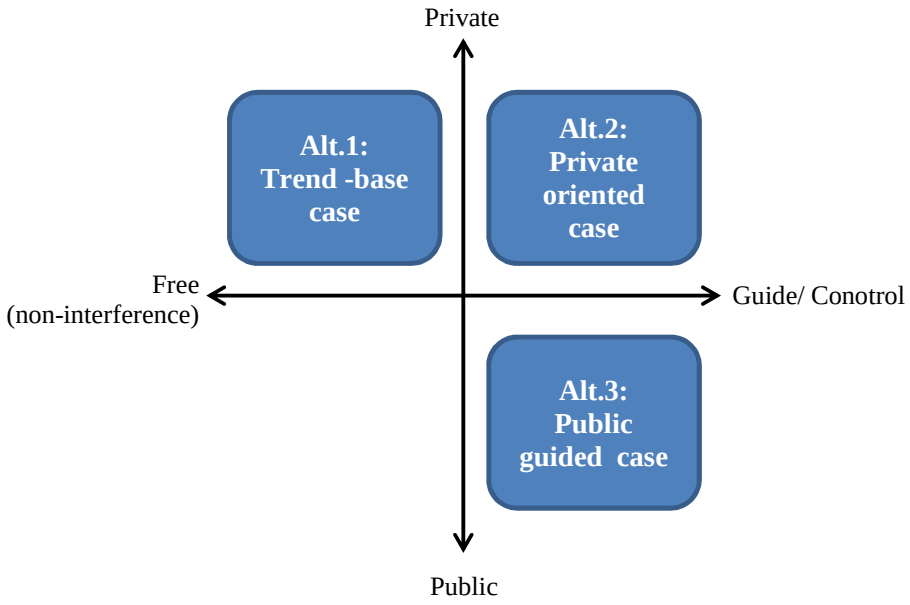
According to the framework, PPCC will have a population of 2.87 million. This means an increase in population of approximately 462 thousand between 2020 and 2035. To accommodate this increased number, PPCC is required to expand its urban area by 46.2 km^2.

In other words, the urban structure in 2035 will expand to approximately 210 ha by adding 46.2 km^2 to the new urban area of 2020.

2) Alternatives

There was little public intervention for guidance/ control of urban development by the urban planning authorities in PPCC. Accordingly, PPCC has been expanded as a result of individual building construction activities. Since area at road side is convenient for transport and utility supply, urbanization concentrates along the major roads. Currently, the private sector invests in large-scale urban development projects in PPCC on one hand, and government system and capacities are gradually enhanced to deal with urban problems. Accordingly, it is importance for the examination of future urban structure to anticipate the following determinants of urban development as shown in Figure 4.2-7:

- Degree of free (non-interference) and guidance/control of urban development
- Involvement of private and public sectors in development



Source: PPUTMP Project Team

Figure 4.2-7 Alternatives on Future Urban Structure in 2035

Based on the figure, the PPUTMP Project Team delineates three typical future land use prospects anticipated as follows:

- Alternative 1: Trend-based case
- Alternative 2: Private-oriented case
- Alternative 3: Public-private collaboration case

(2) Alternative 1: Trend-based Case

1) Urban Area

The total urbanized area will be approximately 210 km^2 in 2035 to accommodate a population of approximately 2.9 million.

Trend-based case is considered to follow current urban expansion mainly along the major rods without or with little governmental interference. Development is made with mainly individual building construction with some private development projects. Urban expansion along the road will be a major driving force. Private development will provide certain new urban areas. Public sector will have limited improvement of institutional, human and financial capacity to guide/ control urbanization even until 2035. Major urban expansion from 2020 to 2035 is as follows:

- Urban area in 2020 continues to expand in the same direction of urbanization until 2020, which is along major roads to north (NR5 and NR6), south (NR1, NR2, NR3) and west (NR4) directions;
- Urban area in 2020 expands built-up areas to the areas behind from road side; and
- Industrial area is expanded in the west and north directions along NR4 and RR-III.

2) Land Use and Intensity

Land use intensity will rise from center to fringe in this case. High density areas will expand up to Mao Tse Toung while those of medium density will expand outside IRR mainly to the west direction.

- Inside IRR: high and medium density mixed land use
- Outside IRR: medium density at private development areas and the area along NR4, the other area, low density
- Industrial areas along Chaom Chau Road, NR4 and RR-III
- Industrial areas at RR-II/NR1 and at RR-III/NR6
- Other mainly outside of RR-III: Green and farm land, water body, vacant land, etc.

3) Urban Centers

Economic activities such as service, finance, commerce and trade are more concentrated in the urban centers. On the other hand, the area along RR-III and the railway will receive more factories and logistics facilities. Anticipated urban centers with high density areas are:

- Urban Center (Boueng Kok, Monivong, Diamond City)
- 8 Sub-centers (Chbar Ampov, Chak Angrae Kraom, Kandal, Stueng Mean Chey, Cheung Aek, Phleung Chheh Roteh, Grand Phnom Penh, Camko City)
- Production Center (Chaom Chau, RR-III)
- 2 Production Sub-centers (Preaek Aeng, Bak Kaeng)

4) Transport Network

The transport Network in 2035 basically expands the network in 2020 in accordance with urban expansion. Major transport nodes and network are as follows:

Major transport node:

- Phnom Penh Port, New Phnom Penh Port, International Airport (Planned New International Airport located at Kampong Chhnang)

Major transport corridor:

- North-South Transport Corridor including 5 sub-corridors supports the urban institutional, business and commercial activities
- East-West Transport Corridor including 3 sub-corridors supports the urban industrial and commodity activities
- Ring Transport Corridor (Grand Phnom Penh - Stueng Mean Chey) supports the urban connectivity

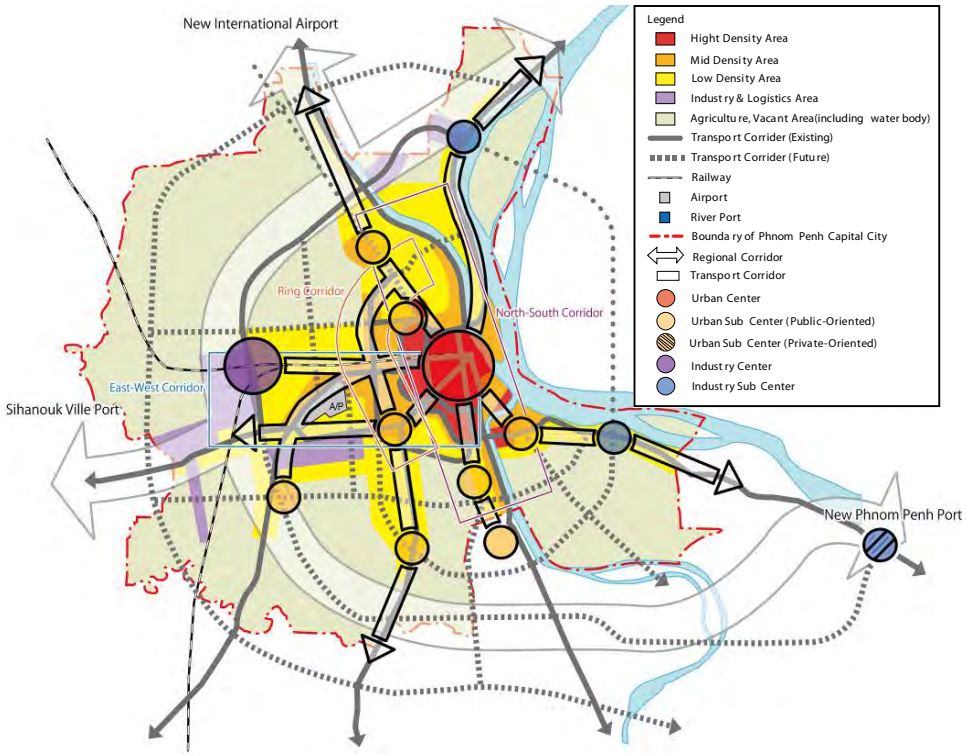
Regional corridor:

- Growth Corridor and Indochina Central Corridor: Sihanoukville - NR4 - PPCC - NR6
- Indochina Southern Corridor: NR1 - PPCC - NR5

Mode interchange area:

- Both ends and intersection of major transport corridors

The abovementioned urban structure is conceptually illustrated in Figure 4.2-8.



Source: PPUTMP Project Team

Figure 4.2-8 Alternative 1: Urban Structure in 2035

(3) Alternative 2: Private-oriented Case

1) Urban Area

The total urbanized area will be approximately 210 km^2 in 2035 to accommodate a population of approximately 2.9.

Private-oriented case assumes more real estate businesses contribute to form a major part of urban expansion. Currently large-sized residential development is planned like Green City, Satellite City and

Boeung Chuuk area development. If current urban development projects are a success, it is expected that there will be more foreign investment to the real estate business in PPCC under favorable economic condition and population growth. Major urban expansion from 2020 to 2035 is as follows:

- Large private urban development projects indicated in Figure 4.2-3 are completed and accommodate sufficient population. Other private residential estate development projects are also carried out;
- Urban area in 2020 continues to expand mainly to the west (NR4) direction;
- Urban area in 2020 expands built-up areas to the areas behind from road side; and
- Industrial area is expanded in the west and north directions along NR4 and RR-III.

2) Land Use and Intensity

Land use intensity will rise from center to fringe in this case. High density areas will expand up to Mao Tse Toung, while those of medium density will expand over IRR mainly to the west direction.

- Inside IRR: high and medium density mixed land use
- Outside IRR: mid-density at private development areas and the area along NR4, the other area low density
- Industrial areas along Chaom Chau Road, NR4 and RR-III
- Industrial areas RR-II/NR1 and at RR-III/NR6
- Other mainly outside RR-III: Green and farm land, water body, vacant land, etc.

3) Urban Centers

Locations and urban centers are the same as that of Alternative 1. Anticipated urban centers with high density areas are:

- Urban Center (Boueng Kok, Monivong, Diamond City)
- 8 Sub-centers (Chbar Ampov, Chak Angrae Kraom, Kandal, Stueng Mean Chey, Cheung Aek, Phleung Chheh Roteh, Grand Phnom Penh, Camko City)
- Production Center (Chaom Chau, RR-III)
- 2 Production Sub-centers (Preaek Aeng, Bak Kaeng)

4) Transport Network

The transport Network in 2035 basically expands the network in 2020 in accordance with urban expansion. The network should also be developed to cover the southern direction, in which many large urban development projects are completed. Major transport nodes and network are as follows:

Major transport node:

- Phnom Penh Port, New Phnom Penh Port, International Airport (Planned New International Airport located at Kampong Chhnang)

Major transport corridor:

- North-South Transport Corridor including 5 sub-corridors supports the urban institutional, business and commercial activities
- East-West Transport Corridor including 3 sub-corridors supports the urban industrial and commodity activities
- Ring Transport Corridor (Grand Phnom Penh - Stueng Mean Chey) supports the urban connectivity

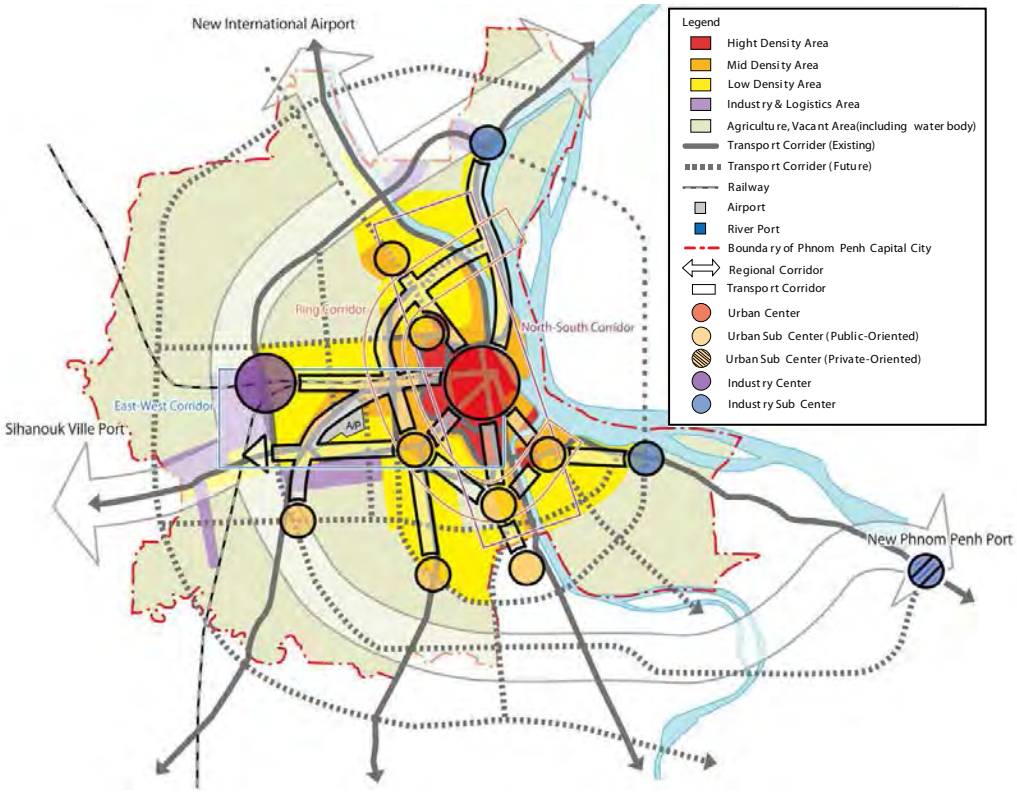
Regional corridor:

- Growth Corridor and Indochina Central Corridor: Sihanoukville - NR4 - PPCC - NR6
- Indochina Southern Corridor: NR1 - PPCC - NR5

Mode interchange area:

- Both ends and intersection of major transport corridors

The abovementioned urban structure is conceptually illustrated in Figure 4.2-9.



Source: PPUTMP Project Team

Figure 4.2-9 Alternative 2: Urban Structure in 2035

(4) Alternative 3: Public-private collaboration Case

1) Urban Area

The total urbanized area will be approximately 210 km^2 in 2035 to accommodate a population of approximately 2.9 million.

In this case, public sector guides private investment to certain areas by institutional control and infrastructure provision. PPCC has an example: Toul Kork area, which has a system of ring and radial roads, was developed under urban planning and design in the late 1960s. This needs institutional, human and financial capabilities of public agencies concerned with urban development administration. The Cambodian government has been gradually enhancing its capacity with foreign assistance, so that there seems to be a potential to prepare certain measures to guide urban development with new town development like the Toul Kork. To improve the efficiency and effectiveness of logistics and production, the government designates a special zone for concentrating logistics and industrial activities around the intersection of RR-III and the south line of the railway.
Major directions of urban expansion from 2020 to 2035 are as follows:

- Large public investment will be made for constructing transport network and utilities at the north-east area to guide private investment of housing and real estate development. This area will form a new urbanized area;
- Urban area in 2020 continues to expand mainly to the west (NR4) direction;
- Urban area in 2020 expands built-up areas to the areas behind from road side; and
- Logistics and industrial complex will be formulated by government initiatives to where existing factories and warehouses in downtown shall be relocated. The area is around the intersection of RR-III and the south line of the railway.

2) Land Use and Intensity

Land use intensity will rise from center to fringe in this case. High density areas will expand up to Mao Tse Toung, while those of medium density will expand over IRR mainly to the west direction.

- Inside IRR: high and medium density mixed land use
- Outside IRR: medium density at private development areas and the area along NR4, the other area, low density
- Industrial areas along Chaom Chau Road, NR4 and RR-III
- Industrial areas at RR-II/NR1 and at RR-III/NR6
- Other mainly outside RR-III: Green and farm land, water body, vacant land, etc.

3) Urban Centers

In addition to the urban centers mentioned for Alternatives 1 and 2, Krang Thnong is designated as a sub-center, which is a neighboring center of the new urbanized area. Anticipated urban centers with high or medium density areas are:

- Urban Center (Boueng Kok, Monivong, Diamond City)
- 9 Sub-centers (Chbar Ampov, Chak Angrae Kraom, Kandal, Stueng Mean Chey, Cheung Aek, Phleung Chheh Roteh, Krang Thnong, Grand Phnom Penh, Camko City)
- Production Center (Chaom Chau, RR-III)
- 2 Production Sub-centers (Preaek Aeng, Bak Kaeng)

4) Transport Network

The transport Network in 2035 basically expands the network in 2020 in accordance with urban expansion. The network should also be developed to cover the southern direction, in which many large urban development projects are completed. Major transport nodes and network are as follows:

Major transport node:

- Phnom Penh Port, New Phnom Penh Port, International Airport (Planned New International Airport located at Kampong Chhnang)

Major transport corridor:

- North-South Transport Corridor including 5 sub-corridors supports the urban institutional, business and commercial activities
- East-West Transport Corridor including 3 sub-corridors supports the urban industrial and commodity activities
- New Urban Sub-center Transport Corridor (Urban Center - Krang Thnong) supports the urban activities in the new urban sub-center
- Ring Transport Corridor (Grand Phnom Penh - Stueng Mean Chey) supports the urban connectivity

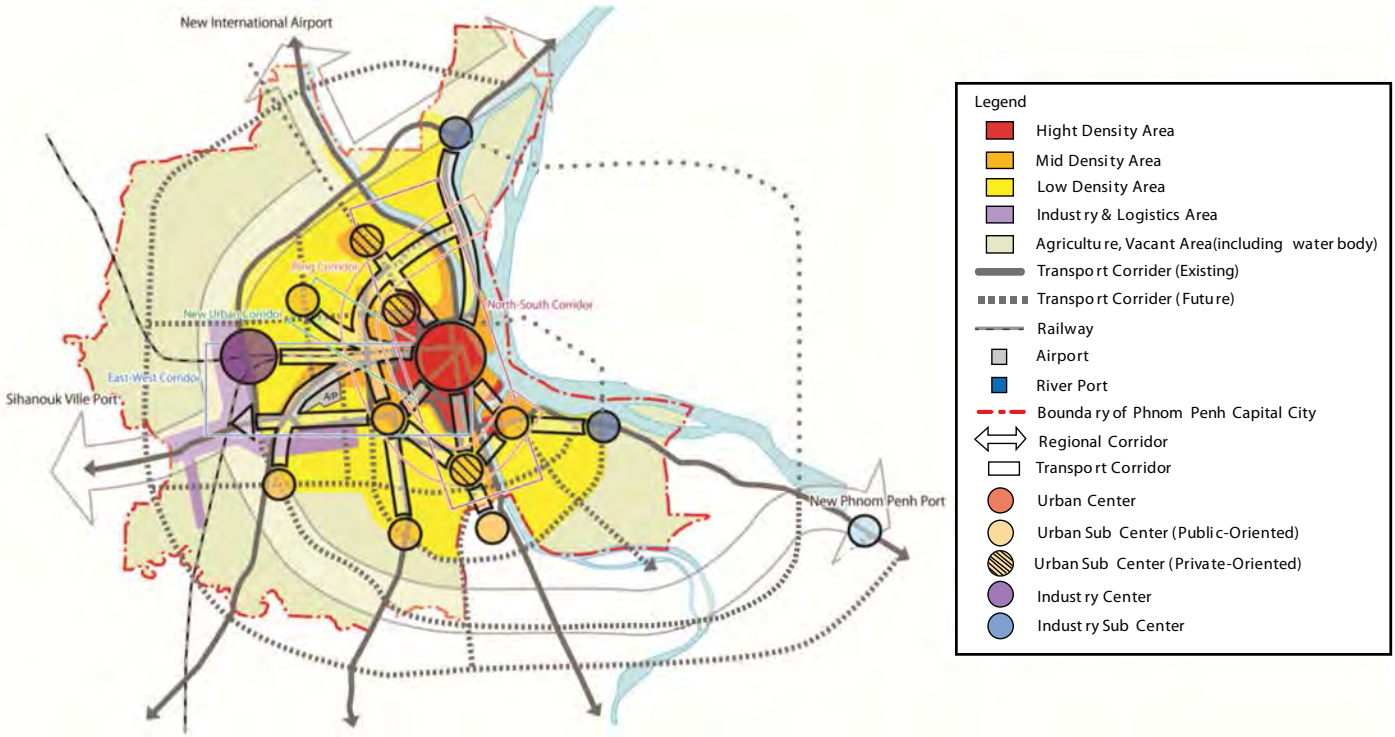
Regional corridor:

- Growth Corridor and Indochina Central Corridor: Sihanoukville - NR4 - PPCC - NR6
- Indochina Southern Corridor: NR1 - PPCC - NR5

Mode interchange area:

- Both ends and intersection of major transport corridors

The concept for Alternative 3 shows a pear-shaped structure as shown in Figure 4.2-10.



Source: PPUTMP Project Team

Figure 4.2-10 Alternative 3: Urban Structure in 2035

(5) Evaluation of Alternatives

1) Criteria

The alternatives indicated above could accommodate requirements from development visions and preconditions. However, there are different advantages and disadvantages one from the other. The best alternative shall be selected based on the following criteria:

- Environment (impacts on further environment improvement projects)
- Traffic (impacts on traffic conditions)
- Cost (to realize the structure by public sector)
- Public Enforcement (Intervention) for controlling /guiding development (to realize the structure)
- Project risk (dependence on private sector investment)
- Suburban development (to provide residential areas with good accessibility and environment for low and medium income groups by public intervention)

2) Results of Evaluation

The PPUTMP Project Team selected "Public-private collaboration case" of Alternative 3, which may have more advantages to generate a better environment through a holistic approach in the suburban area compared to others. However it is important to acknowledge that sufficient capacity of public sector in terms of investment and institution to guide urbanization and urban development are required to materialize the structure.

Table 4.2-4 Evaluation of Alternatives

	Alternative 1: Trend-base Case	Alternative 2: Private-oriented Case	Alternative 3: Public-private collaboration Case
Natural Environment	1 There is no vulnerable fauna and flora in the urban area in Phnom Penh, so that there is little impact on natural environment from urbanization which seems to be negligible difference among the alternatives. Green belt areas, consisting of agricultural land and forest land, surrounding Phnom Penh will be deteriorated with disordered urbanization.	2 There is no vulnerable fauna and flora in the urban area in Phnom Penh, so that there is little impact on natural environment from urbanization which seems to be negligible difference among the alternatives. Green belt areas, consisting of agricultural land and forest land, surrounding Phnom Penh will be affected with development along roads, but it may be limited.	2 There is no vulnerable fauna and flora in the urban area in Phnom Penh, so that there is little impact on natural environment from urbanization which seems to be negligible difference among the alternatives. Green belt areas, consisting of agricultural land and forest land, surrounding Phnom Penh will be affected with development along roads, but it may be limited.
Living Environment	1 Environmental burden on living circumstance can not be released in urban center. Sprawl type of urban area will be generated along the major roads, resulted in expanding insufficient urban environmental areas in the suburban area.	2 Environmental burden on living circumstances can be released in certain degree in urban center by removing businesses to sub-centers. Residential area with better environment shall be expanded with large urban development projects.	3 Environmental burden on living circumstances can be released in certain degree in urban center by removing businesses to sub-centers. Residential area with better environment shall be expanded in the public guided new urbanized area which ha sufficient infrastructure and utilities.
Traffic Impact	1 There is a risk to generate heavy traffic congestion in the urban center in future.	3 High mobility can be maintained with distribution of traffic attractions.	3 High mobility can be maintained with distribution of traffic attractions.
Cost	3 Less public investment is required to develop infrastructure and utility in the sub-centers.	2 Certain level of public investment is required to accelerate public investment for housing and real estate businesses.	1 More public investment is required to develop infrastructure and utility to guide private development projects to the new urbanized area.
Enforcement	3 It is possible to manage with current institution and capacity regarding urban development management.	2 It is required to improve urban development and management capacity in urban planning authority.	1 It is required to improve urban development and management capacity in urban planning authority. More capacity is necessary comparing to the alternative 2.
Project Risk	3 Less influence from large urban development projects	1 Urban structure depends totally on large urban development projects by the private investment.	2 Dependence on the public investment and capacity
Suburban Development	1 There is a risk to cause urban sprawl along the major roads in the suburban area. Industrial area will be naturally formed along N0.4 and outer ring roads. Residential area will be formed along the major roads.	2 There is a risk to generate disordered private development without sufficient public control capacity. Industrial area will be naturally formed along N0.4 and outer ring roads. Residential area will be mainly formed at the private initiated large scale urban development areas and certain areas along the major roads (but it much smaller than the Alterative 1).	3 It is possible to improve living environment (conditions) of existing relocation sites in the northeastern part of Phnom Penh with good impacts from development of nearby areas. Industrial area will be intentionally formed mainly tag the intercession area of outer ring road with railway with certain accumulation along No.4 (but it is limited). Residential area will be intentionally located at north-eastern area between C2 and C3 to form a planned urbanized area.
Total	13	14	15

Source: PPUTMP Project Team

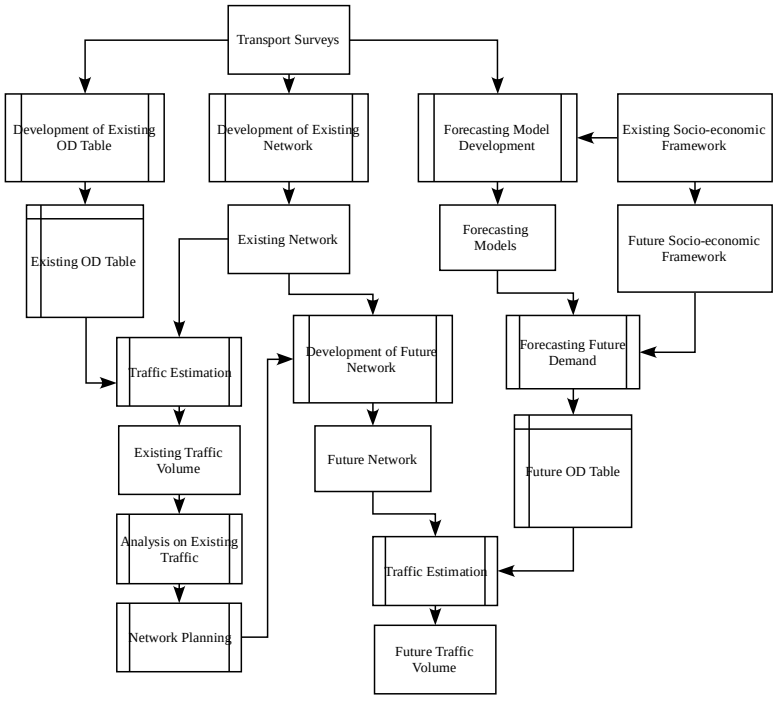
5 TRAFFIC DEMAND FORECAST

5.1 Forecasting Approach

5.1.1 Transport Demand Forecasting and Network Planning

Future transport demand will be estimated based on a traditional and established approach that is sometimes called four-step methodology. This approach consists of a part that estimates demand of moving subjects and compiles the demand in matrix form called Origin-Destination (OD) table and a part that estimates traffic volume by distributing the OD table on a network representing transport service in a target project area. In transport demand forecasting, there are two OD tables needed: one is the present OD table to represent the existing transport situation, and this will be established by compiling the results of the transport surveys and interviews conducted in the project. The other is the future OD table that will be estimated according to the abovementioned approach based on the present OD table, taking into account the existing transport features, future urban structure, and future socio-economic frame.

On the other hand, a network that is a set of nodes and links used for assignment process will be constructed by modeling of the represented transport service such as the road network. Each link, which is a connection of intersections, should have information about capacity and travel speed reflecting the existing transport condition, to search the minimum cost route on which travel demand will be loaded in order to calculate traffic volume. This process is called assignment, and several cases of travel demand and network combinations, for example, present travel demand and present network, future travel demand and present network, and future travel demand and future network, will be examined in this process. Especially, the case of future travel demand and present network is called “Do Nothing” case, which means no project is realized for the future demand as a basis for future planning.
A flowchart of transport demand forecasting performed in this study is shown in Figure 5.1-1 below.



Source: PPUTMP Project Team

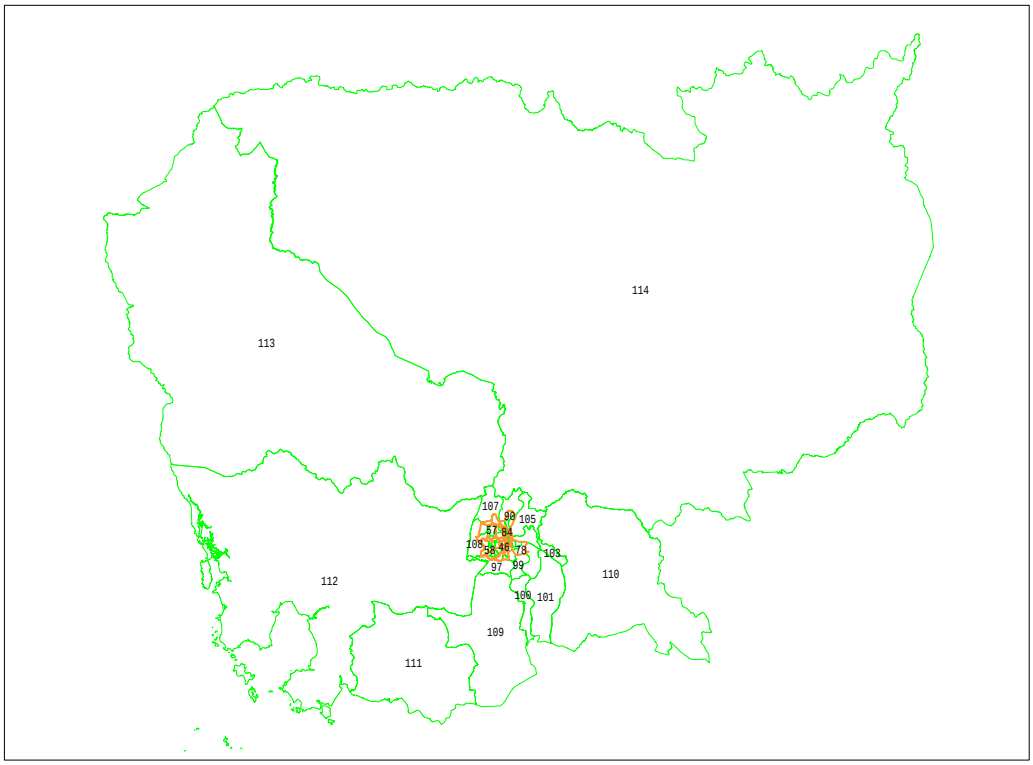
Figure 5.1-1 Transport Demand Forecasting and Network Planning

5.1.2 Issues for Forecasting Approach

(1) Traffic Analysis Zone (TAZ)

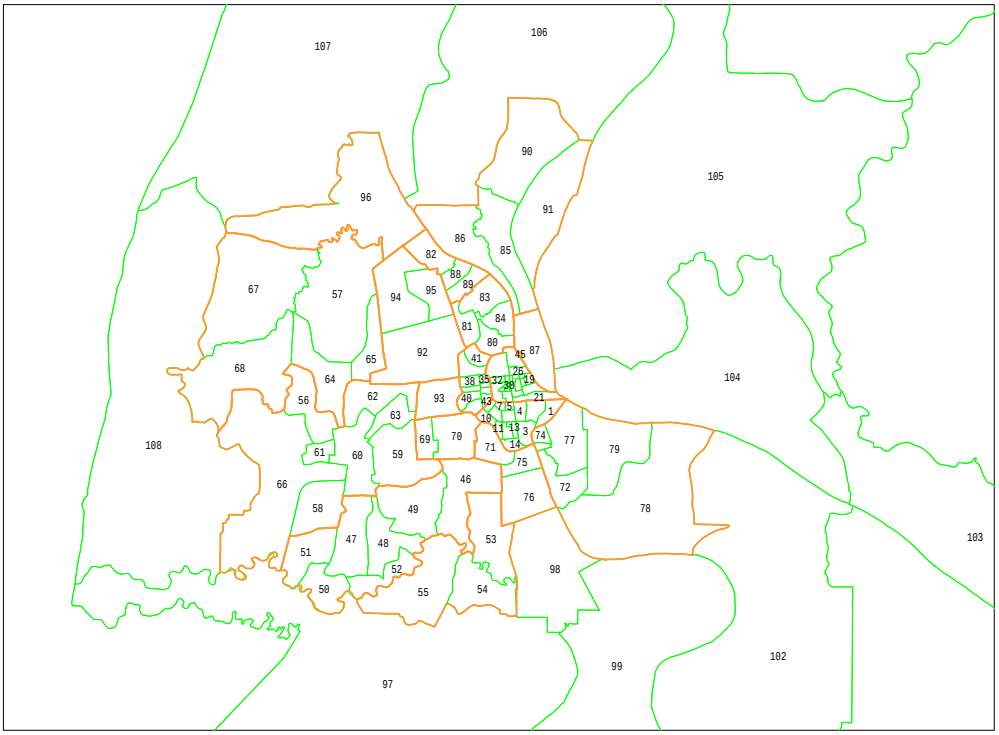
As mentioned above, key tasks in transport demand forecasting are to establish OD tables and to develop a transportation network. An OD table expresses the volume of travel activities, such as passenger travel and cargo movement, that takes place from one given location to another. These given locations are generally aggregated into areas, for example, city blocks, communities, or districts. An activity to define zones is called zoning and the defined zones are called Traffic Analysis Zones (TAZs) in this project.

Based on the zoning performed in the Project, there are 45 zones in the urban area, 51 in the suburban area, and 21 for external areas. These are shown in the following figures with details provided in Tables 5.1-1 and 5.1-2.



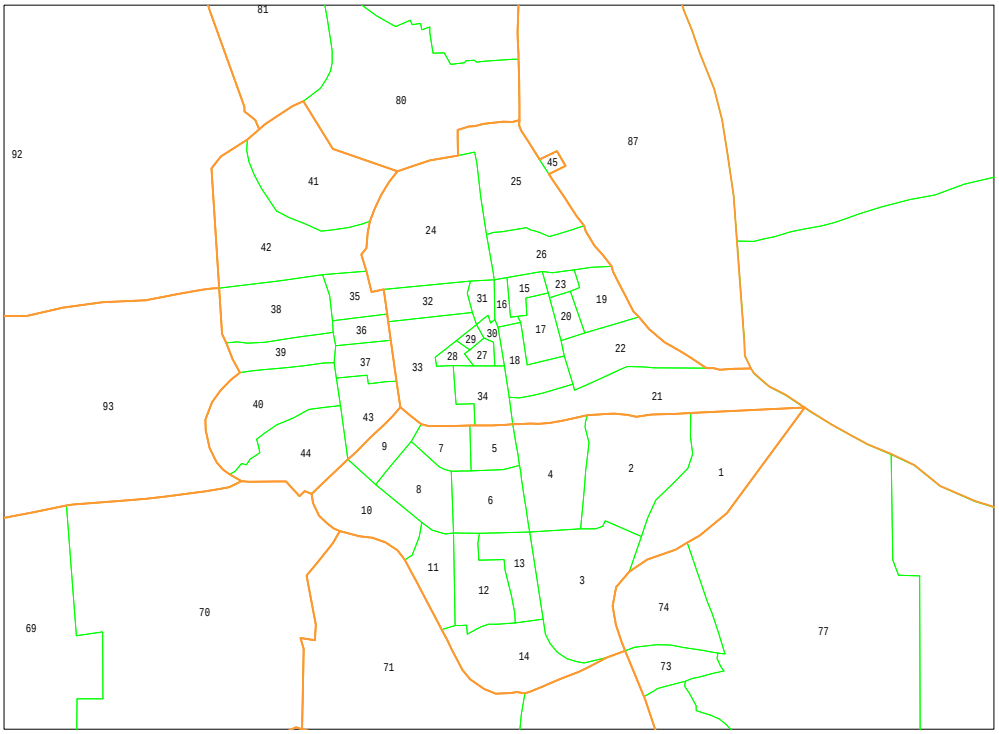
Source: PPUTMP Project Team

Figure 5.1-2 TAZ (Cambodia Overall)



Source: PPUTMP Project Team

Figure 5.1-3 TAZ (Project Area)



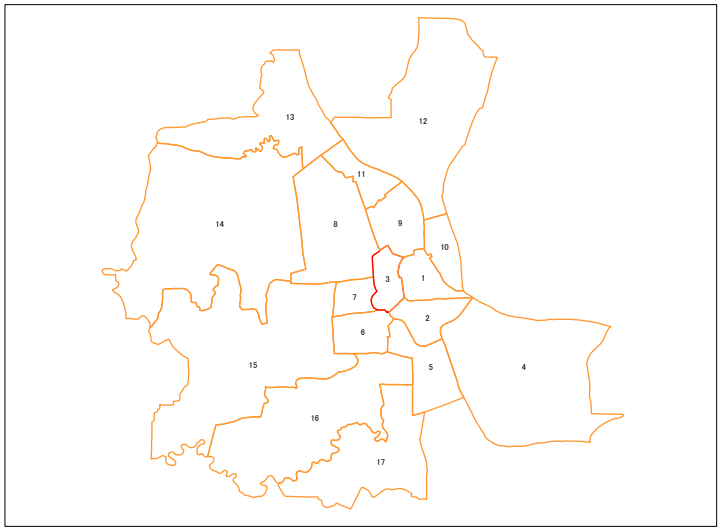
Source: PPUTMP Project Team

Figure 5.1-4 TAZ (Urban Area)

Table 5.1-1 Definition of Traffic Analysis Zones (TAZs)

District	Zone Code	Community	Code2008	District	Zone Code	Community	Code2008
1201 Chamkar Mon	1	Tonle Basak	120101	1205 Posen Chey	56	Trapeang Krasang	120502
	2	Tonle Basak	120101		57	Kouk Roka	120503
	3	Tonle Basak	120101		58	Phleung Chheh Roteh	120504
	4	Boeng Keng Kang Muoy	120102		59	Chaom Chau	120505
	5	Boeng Keng Kang Pir	120103		60	Chaom Chau	120505
	6	Boeng Keng Kang Bei	120104		61	Chaom Chau	120505
	7	Oulampik	120105		62	Kakab	120506
	8	Tuol SvayPreyTiMuoy	120106		63	Kakab	120506
	9	Tuol SvayPreyTiPir	120107		64	Samraong Kraom	120509
	10	Tumnob Tuek	120108		65	Krang Thnong	120511
	11	Tuol TumpungTiPir	120109		66	Boeung Thom	120521
	12	Tuol TumpungTiMuoy	120110			Kambol	120522
	13	Boeng Trabaek	120111			Kantork	120523
	14	Phsar Daeum Thkov	120112		67	Ov leok	120524
1202 Doun Penh	15	PhsarThmeiTiMuoy	120201		68	Pon sang	120525
	16	PhsarThmeiTiPir	120202			Snor	120526
	17	PhsarThmeiTiBei	120203	1206 Mean Chey	69	Stueng Mean Chey	120601
	18	Boeng Reang	120204		70	Stueng Mean Chey	120601
	19	PhsarKandalTiMouy	120205		71	Boeng Tumpun	120602
	20	PhsarKandalTiPir	120206		72	Preaek Pra	120603
	21	Chakto Mukh	120207		73	Chhbar AmpovTiMuoy	120604
	22	CheyChummeah	120208		74	Chhbar AmpovTiPir	120605
	23	PhsarChas	120209		75	Chak AngraeLeu	120606
	24	SrahChak	120210		76	Chak AngraeKraom	120607
	25	SrahChak	120210		77	Nirouth	120608
	26	VoatPhnum	120211		78	Kbal Koh	120609
1203 Prampir Meakkara	27	Ou Ruessei Ti Muoy	120301			Prek Thmei	120611
	28	Ou Ruessei Ti Pir	120302		79	Prek Eng	120610
	29	Ou Ruessei Ti Bei	120303			Veal Sbov	120612
	30	Ou Ruessei Ti Buon	120304	1207 Russey Kaev	80	TuolSangkae	120702
	31	Monourom	120305		81	Toul Sangkae (Camko City)	120702
	32	Mittakpheap	120306		82	Svay Pak	120703
	33	Veal Vong	120307		83	Kilomaetr Lekh Prammuoy	120704
	34	Boeng Prolit	120308		84	Ruessei Kaev	120706
1204Toul Kouk	35	Phsar Depou Ti Muoy	120401		85	Preaek Lieb	120708
	36	Phsar Depou Ti Pir	120402		86	Preaek Ta Sek	120709
	37	Phsar Depou Ti Bei	120403		87	Chrouy Changvar	120710
	38	Tuek L'ak Ti Muoy	120404		88	Chrang Chamreh Ti Muoy	120711
	39	Tuek L'ak Ti Pir	120405		89	Chrang Chamreh Ti Pir	120712
	40	Tuek L'ak Ti Bei	120406		90	Bakkeng	120713
	41	Boeng Kak Ti Muoy	120407		91	Kosh Dach	120714
	42	Boeng Kak Ti Pir	120408	1208 Sen Sok	92	Phnom Penh Thmei	120801
	43	Phsar Daeum Kor	120409		93	TuekThla	120802
	44	Boeng Salang	120410		94	Khmuonh	120803
	45	Phnom Penh Port	120411		95	Khmuonh	120803
1205 Dang Kao	46	Dangkao	120501		96	Pongea Pon	120804
	47	Pong Tuek	120507			Prek Phnov	120805
	48	Preyveaeng	120508			Samrong	120806
	49	Prey Sa	120510	External	97	KandalStueng (Exclud Kong Noy, Preak	
	50	Krang Pongro	120512		98	Krong Ta Khmau: (Ta kdol, Preak Russei,	
	51	Prateaah Lang	120513		99	S'ang : (Kaoh Anloung Chen, Prek Koy,	
	52	Sak Sampov	120514		100	S'ang & Kaoh Thum: (Kaoh Khel, Kaoh	
	53	Cheung Aek	120515		101	1Kien Svy (Banteay Daek, Kokir Thum,	
	54	Prek Kampeus	120517		102	1Kien Svay (Chheu Teal, Dei Edth,	
	55	Kong Noy	120516		103	LveaAem (Boeung Krum, Kaoh Kaev,	
		Rolous	120518		104	LveaAem (Exclud 103)	
		Spean Thmor	120519		105	Khsach Kandal	
		Tien	120520		106	Mukh Kampul (Exclud Baek Keng, Kaoh	
					107	Popnhea Lueu (Include Tuol Prech of Angk	
					108	Angk Snoul (Exclud Tuol Prech, Pong	
					109	Takeo	
					110	Prey Veng & Svay Rieng	
					111	Kampot, Kep, Sihanouk ville	
					112	Kampong Speu, Koh Kong	
					113	Kampong Chhnang, Pursat, Battam Bang,	
					114	Kampong Cham, Kampong Thom, Kratie,	
					115	Vietname	
					116	Laos	
					117	Thailand	

Source: PPUTMP Project Team



Source: PPUTMP Project Team

Figure 5.1-5 Integrated Zones

Table 5.1-2 Definition of Integrated Zones (ITAZs)

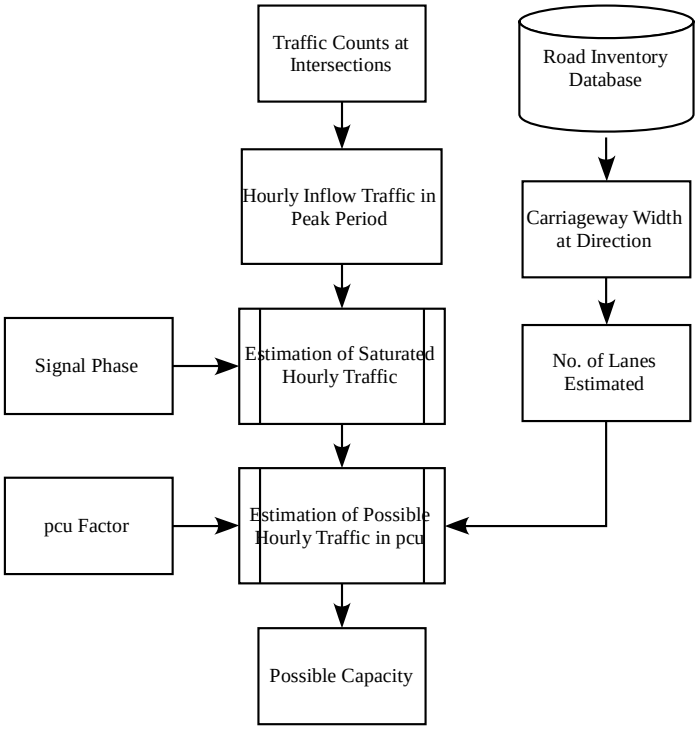
Integrated Zone	District	Zone Code	Community	Integrated Zone	District	Zone Code	Community
1	1202 Doun Penh	15	PhsarThmeiTiMuoy	5	1206 Mean Chey	71	Boeng Tumpun
1		16	PhsarThmeiTiPir	5		75	Chak AngraeLeu
1		17	PhsarThmeiTiBei	5		76	Chak AngraeKraom
1		18	Boeng Reang	6	1206 Mean Chey	69	Stueng Mean Chey
1		19	PhsarKandalTiMouy	6		70	Stueng Mean Chey
1		20	PhsarKandalTiPir	7	1208 Sen Sok	93	TuekThla
1		21	Chakto Mukh	8	1208 Sen Sok	92	Phnom Penh Thmei
1		22	CheyChummeah	8		94	Khmuonh
1		23	PhsarChas	8		95	Khmuonh
1		24	SrahChak	9	1207 Russey Kaev	80	TuolSangkae
1		25	SrahChak	9		81	Toul Sangkae (Camko City)
1		26	VoatPhnum	9		83	Kilomaetr Lekh Prammuoy
1		27	Ou Ruessei Ti Muoy	9		84	Ruessei Kaev
1		28	Ou Ruessei Ti Pir	10	1207 Russey Kaev	87	Chrouy Changvar
1		29	Ou Ruessei Ti Bei	11	1207 Russey Kaev	82	Svay Pak
1		30	Ou Ruessei Ti Buon	11		88	Chrang Chamreh Ti Muoy
1		31	Monourom	11		89	Chrang Chamreh Ti Pir
1		32	Mittakpheap	12	1207 Russey Kaev	85	Preaek Lieb
1		33	Veal Vong	12		86	Preaek Ta Sek
1		34	Boeng Prolit	12		90	Bakkeng
1		45	Phnom Penh Port	12		91	Kosh Dach
2	1201 Chamkar Mon	1	Tonle Basak	13	1208 Sen Sok	96	Pongea Pon
2		2	Tonle Basak	14	1205 Posen Chey	57	Kouk Roka
2		3	Tonle Basak	14		64	Samraong Kraom
2		4	Boeng Keng Kang Muoy	14		65	Krang Thnong
2		5	Boeng Keng Kang Pir	14		67	Ov leok
2		6	Boeng Keng Kang Bei	14		68	Pon sang
2		7	Oulampik	15	1205 Posen Chey	56	Trapeang Krasang
2		8	Tuol SvayPreyTiMuoy	15		58	Phleung Chheh Roteh
2		9	Tuol SvayPreyTiPir	15		59	Chaom Chau
2		10	Tumnob Tuek	15		60	Chaom Chau
2		11	Tuol TumpungTiPir	15		61	Chaom Chau
2		12	Tuol TumpungTiMuoy	15		62	Kakab
2		13	Boeng Trabaek	15		63	Kakab
2		14	Phsar Daeum Thkov	15		66	Boeung Thom
3	1204Toul Kouk	35	Phsar Depou Ti Muoy	16	1205 Dang Kao	46	Dangkao
3		36	Phsar Depou Ti Pir	16		47	Pong Tuek
3		37	Phsar Depou Ti Bei	16		48	Preyveaeng
3		38	Tuek L'ak Ti Muoy	16		49	Prey Sa
3		39	Tuek L'ak Ti Pir	16		50	Krang Pongro
3		40	Tuek L'ak Ti Bei	16		51	Prateaah Lang
3		41	Boeng Kak Ti Muoy	16		52	Sak Sampov
3		42	Boeng Kak Ti Pir	17	1205 Dang Kao	53	Cheung Aek
3		43	Phsar Daeum Kor	17		54	Prek Kampeus
3		44	Boeng Salang	17		55	Kong Noy
4	1206 Mean Chey	72	Preaek Pra				
4		73	Chhbar AmpovTiMuoy				
4		74	Chhbar AmpovTiPir				
4		77	Nirouth				
4		78	Kbal Koh				
4		79	Prek Eng				

Source: PPUTMP Project Team

(2) Motorbike Passenger Car Unit (PCU) Factor

Analysis and evaluation on transport situation are fundamental matters in each planning phase of urban transport master plans. Situation analysis and evaluation on transportation are, in general, done by using indicators of traffic volume, travel speed, and transport concentration. Among these three, transport concentration is especially important and can be measured with the ratio between volume and capacity at maximum level and possible traffic at each road section.

On the other hand, actual traffic passing on the road varies in mode such as motorbikes, passenger cars, Motorumok and Motorumok Modern (tuk-tuk) rides as para-transit, and trucks as cargo transport. These aforementioned transport modes are distinct in their size and traveling behavior and have considerable influence in the calculation of capacity. Generally, capacity is frequently expressed in terms of PCU. It is an important issue to specify and analyze what the PCU value of motorbikes is in the case of a motorbike-dominant city like Phnom Penh Capital City (PPCC).



Source: PPUTMP Project Team

Figure 5.1-6 Flowchart of Motorbike PCU Examination

In defining the motorbike's PCU, an examination is conducted as shown in Figure 5.1-6 above. Inflow traffic at major intersections in the urban area was counted for 24 hours and the vehicle counts every 15 minutes were recorded by 10 types of vehicles. These vehicle counts during peak periods can be viewed as saturated traffic if the flow is not interrupted during green time, and hourly possible capacity per lane can be estimated in terms of PCU based on the saturated traffic. Moreover, the number of lanes at inflow of intersections is assumed with the following equation.

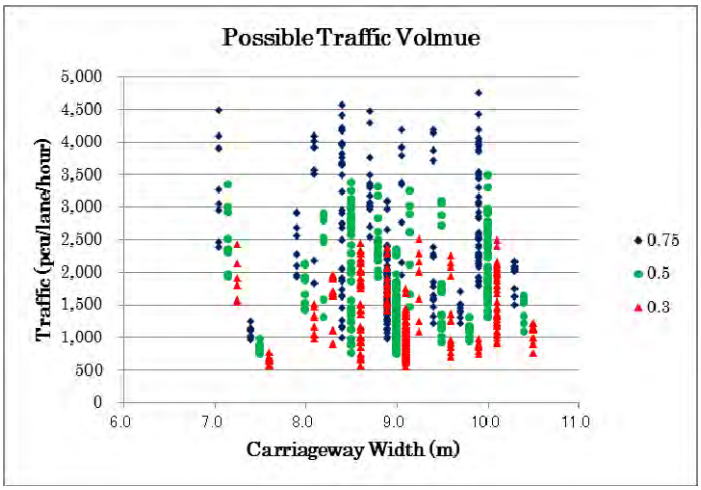
$$N = \text{int}(W / 1.75) / 2$$

Where, N = Number of lanes at inflow of intersection
W = Carriageway width at inflow of intersection (m)
int() = Integerizing

The calculation of hourly possible capacity was done for the following three cases:

Motorbike PCU = 0.3
Motorbike PCU = 0.5
Motorbike PCU = 0.75

The result of calculation is exhibited in Figure 5.1-7, where the x axis shows the carriageway width of each intersection and the y axis shows the hourly possible capacity per lane. This scatter graph might show that there is the same upper limit of capacity in every location. This upper limit can be the hourly possible capacity given in Table 5.1-3, and the PPUTMP Project Team takes 0.3 as the motorbike's PCU because it is close to Japanese standard.



Source: PPUTMP Project Team

Figure 5.1-7 Possible Capacity Estimation Results

Table 5.1-3 Hourly Possible Capacity for Three Motorbike PCU Values Examined

Motorbike PCU	Capacity
0.75	4,427
0.5	3,311
0.3	2,418

Source: PPUTMP Project Team

5.2 Existing Transport Characteristics

Generally, the objective of situation analysis of existing transportation is to clarify the urban structure of a study area, its land use, current transport situation, and their effects and issues by analyzing the results of transport surveys, collected information and statistics. However, in this chapter, the existing situation will be analyzed focusing on the development of demand forecasting models as an important step to specify the development direction of demand forecasting models.

The situation analysis of existing transportation for demand forecasting will cover the following basic items:

- Trip rate

- Trip production and attraction (the number of trips by purpose, mode and zone)
- Distribution (origin and destination of travel, travel length)
- Modal share (travel length and travel time by mode)

5.2.1 Vehicle Ownership

The following figure that is prepared with the analysis of the Home Interview Survey (HIS) results illustrates the distribution of households by monthly income level and household vehicle ownership by income group. As shown in Figure 5.2-1 (graph on the left side), 48% of total households, or a population of 180 thousand, belongs to the income bracket of 250 USD to 499 USD. Therefore, the average household income can be estimated at 468 USD per month.

The graph on the right side shows a steady increase in car ownership rates with increase in household income level. In total, household car ownership ratio is 18.5%, while motorbike ownership ratio is 73.8%.

Note: H/H= Household, M/B= Motorbike
Source: PPUTMP Project Team

Figure 5.2-1 Household Income Distribution and Vehicle Ownership

Table 5.2-1 Number of Households by Vehicle Ownership and Income Group

Unit: '000 HHs

Income Group (USD)	HHs with No Vehicles	with 1 M/B	with 2 or more M/Bs	with M/B & Car	with Car	Total
Under 250	11.4	38.8	18.4	4.5	0.3	73.3
250 - 499	13.5	69.8	74.2	21.5	1.0	180.0
500 - 749	3.5	17.7	35.8	21.4	0.6	79.0
750 - 999	0.5	3.8	10.9	9.4	0.2	24.8
1,000 - 1,499	0.2	1.0	5.4	7.2	0.2	14.1
Over 1,500	0.2	0.4	1.0	2.8	0.2	4.6
Total	***29.3***	***131.4***	***145.7***	***66.8***	***2.5***	***375.7***
Rate (%)	7.8	35.0	38.8	17.8	0.7	100.0

Source: PPUTMP Project Team

5.2.2 Number of Trips by Residents

Based on the number of trips produced by residents in the Project area, the total number is estimated at 4.3 million trips in 2012. As shown in Table 5.2-2, trips made by motorbike have the highest share at 51.8%, or 60.9% excluding walking trips. This is followed by bicycle with 9.1% and by "sedan, wagon & van" with 8.0%. But when all private transportation means are considered, the total share of private mode reaches 71.5% including walking trips, or 84.1% excluding walking trips.

Table 5.2-3 gives the number of trips by trip purpose. The number of commuting trips is 850 thousand, or 19.8%, which is the highest share to total trips, followed by “to school” with 620 thousand trips, or 14.4%, and private trips with 488 thousand trips, or 11.4%.

Table 5.2-2 Number of Trips by Mode of Transport

Mode of Transport	No. of Trips ('000)	Share (%)	
		% to total	Excluding "home" trips
Walking	641.9	14.9	
Private Mode	3,070.4	71.5	84.1
Bicycle	389.3	9.1	10.7
Motorbike	2,223.5	51.8	60.9
Sedan, Wagon & Van	342.1	8.0	9.4
Taxi	79.5	1.9	2.2
Others	36.0	0.8	1.0
Public Mode	12.0	0.3	0.3
Mini Bus	11.1	0.3	0.3
Medium & Large Bus	0.9	0.0	0.0
Para-transit	570.5	13.3	15.6
Motodop	324.0	7.5	8.9
Motorumok modern (tuk-tuk)	151.7	3.5	4.2
Motorumok	94.8	2.2	2.6
Total	***4,294.8***	***100.0***	

Source: PPUTMP Project Team

Table 5.2-3 Number of Trips by Trip Purpose

Trip Purpose	All Mode			Excluding Walk Trips		
	No. of Trips ('000)	Share (%)		No. of Trips ('000)	Share (%)	
		% to total	Excluding " home" trips		% to total	Excluding "home" trips
To home	2,111.9	49.2		1,791.7	49.0	
To work	850.4	19.8	39.0	760.6	20.8	40.9
To school	620.4	14.4	28.4	526.8	14.4	28.3
Business	224.4	5.2	10.3	202.7	5.6	10.9
Private	487.6	11.4	22.3	371.1	10.2	19.9
Total	***4,294.8***	***100.0***	***100.0***	***3,652.9***	***100.0***	***100.0***
Share (%)				85.1		

Source: PPUTMP Project Team

5.2.3 Trip Rate by Individual Attribute

The trip rate characteristics are shown in the following tables (Table 5.2-4 to Table 5.2-8). It can be gleaned from the tables that the travel behavior of males and females are very different, especially looking at the trip-maker ratios and trip rates. Females go out less frequently and often walk when they go out, while males go out more frequently and tend to take motorized vehicles. The trip rates of people from 10 to 54 years old are almost the same level. With regard to walk trips, the ratios of the age groups under 20 years are higher than that of the rest of the age groups.

Table 5.2-4 Trip Rates by Gender

Gender	Population ('000)	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
Male	786.6	85.7	2,210.3	2.8	3.3	8.1
Female	925.5	80.3	2,084.5	2.3	2.8	10.4
Total	***1,712.1***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

Source: PPUTMP Project Team

Table 5.2-5 Trip Rates by Age Group

Age Group	Population ('000)	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
5 - 9	126.1	79.5	261.3	2.1	2.6	22.5
10 - 14	125.2	96.9	334.2	2.7	2.8	36.7
15 - 19	185.2	93.1	523.1	2.8	3.0	18.2
20 - 24	208.0	87.7	547.8	2.6	3.0	5.1
25 - 29	201.8	86.0	517.9	2.6	3.0	4.3
30 - 34	184.2	86.6	498.3	2.7	3.1	3.2
35 - 39	119.1	87.3	324.6	2.7	3.1	3.1
40 - 44	129.5	87.3	371.0	2.9	3.3	2.7
45 - 49	122.6	85.4	343.4	2.8	3.3	2.5
50 - 54	98.4	81.5	255.6	2.6	3.2	3.2
55 - 59	71.9	70.7	159.2	2.2	3.1	4.9
60 - 64	58.1	54.1	92.7	1.6	3.0	4.7
65 - 69	37.2	38.8	41.1	1.1	2.9	6.2
70 - 74	21.9	26.0	15.5	0.7	2.7	4.9
75 -	23.1	15.7	9.0	0.4	2.5	11.0
Total	***1,712.1***	***82.8***	***4,294.8***	***2.5***	***3.0***	9.2

Source: PPUTMP Project Team

The trip-maker ratios of workers and students are high at over 90% except for workers in the primary industrial sector, whose number of walk trips, on the other hand, is high. Meanwhile, occupations with the highest trip rate at 4.2 are “transport, communication & driver” and “administrator & manager”.

As to trip rates by household income, the trip rate of those in the income bracket “under 250 USD” is remarkably lower than that of the groups earning more than 250 USD. On the other hand, when the vehicle ownership level goes up, trip rate also increases.

Table 5.2-6 Trip Rates by Occupation

Occupation	Population ('000)	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
Farmer, forestry worker & fisherman	35.5	73.4	76.5	2.2	2.9	9.7
Mining and quarrying	1.4	96.9	4.2	3.0	3.1	11.1
Skilled worker/industrial operator	214.1	93.6	627.5	2.9	3.1	7.3
Clerical worker	7.8	92.8	24.6	3.2	3.4	7.6
Service, shop & market worker	376.1	83.7	892.3	2.4	2.8	3.4
Transport, communication & driver	62.5	98.2	259.9	4.2	4.2	0.4
Police, security guard	50.9	98.5	171.1	3.4	3.4	2.0
Office worker	127.2	98.3	467.7	3.7	3.7	1.0
Engineer & technician	14.9	97.4	51.7	3.5	3.5	1.3
Administrator & manager	22.5	97.7	94.4	4.2	4.3	0.5
Student (under 15yrs. old)	252.8	98.1	672.2	2.7	2.7	30.9
Student (HS & Univ.)	170.7	99.5	513.2	3.0	3.0	12.8
Housewife & househusband	180.9	73.7	325.4	1.8	2.4	5.4
Jobless	155.0	17.8	70.0	0.5	2.5	8.3
Pensioner	31.0	26.4	22.9	0.7	2.8	6.1
Others	8.9	84.4	21.3	2.4	2.8	5.8
Total	***1,712.1***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

Note: HS= High School, Univ. =University
Source: PPUTMP Project Team

Table 5.2-7 Trip Rates by Income Group

Income Group (USD)	Population ('000)	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
Under 250	296.7	77.8	655.0	2.2	2.8	15.1
250 - 499	802.7	83.5	2,003.3	2.5	3.0	10.4
500 - 749	392.9	85.0	1,036.1	2.6	3.1	6.7
750 - 999	123.1	83.4	331.8	2.7	3.2	3.7
1,000 - 1,499	73.8	82.4	201.5	2.7	3.3	2.7
Over 1,500	22.9	80.6	67.0	2.9	3.6	1.6
Total	***1,712***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

Source: PPUTMP Project Team

Table 5.2-8 Trip Rates by Vehicle Ownership

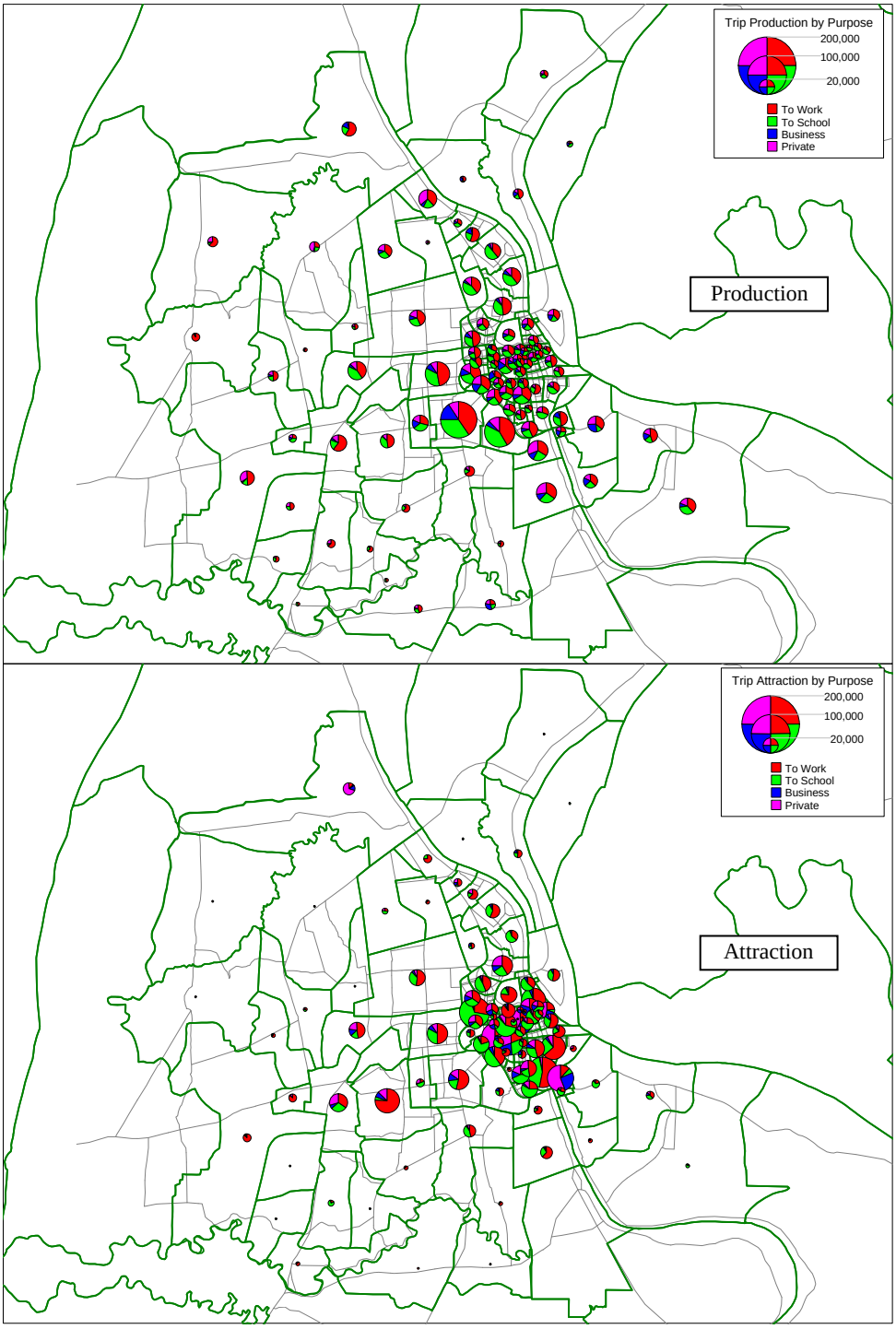
Vehicle Ownership	Population ('000)	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)	Walk Trip Ratio (%)
No vehicles owned	124.9	79.4	289.5	2.3	2.9	17.6
1 M/B	563.0	81.6	1,333.8	2.4	2.9	13.9
2 or more M/Bs	697.6	84.2	1,732.2	2.5	2.9	6.9
Car	326.6	83.1	939.3	2.9	3.5	4.4
Total	***1,712***	***82.8***	***4,294.8***	***2.5***	***3.0***	***9.2***

Source: PPUTMP Project Team

5.2.4 Trip Productions and Attractions

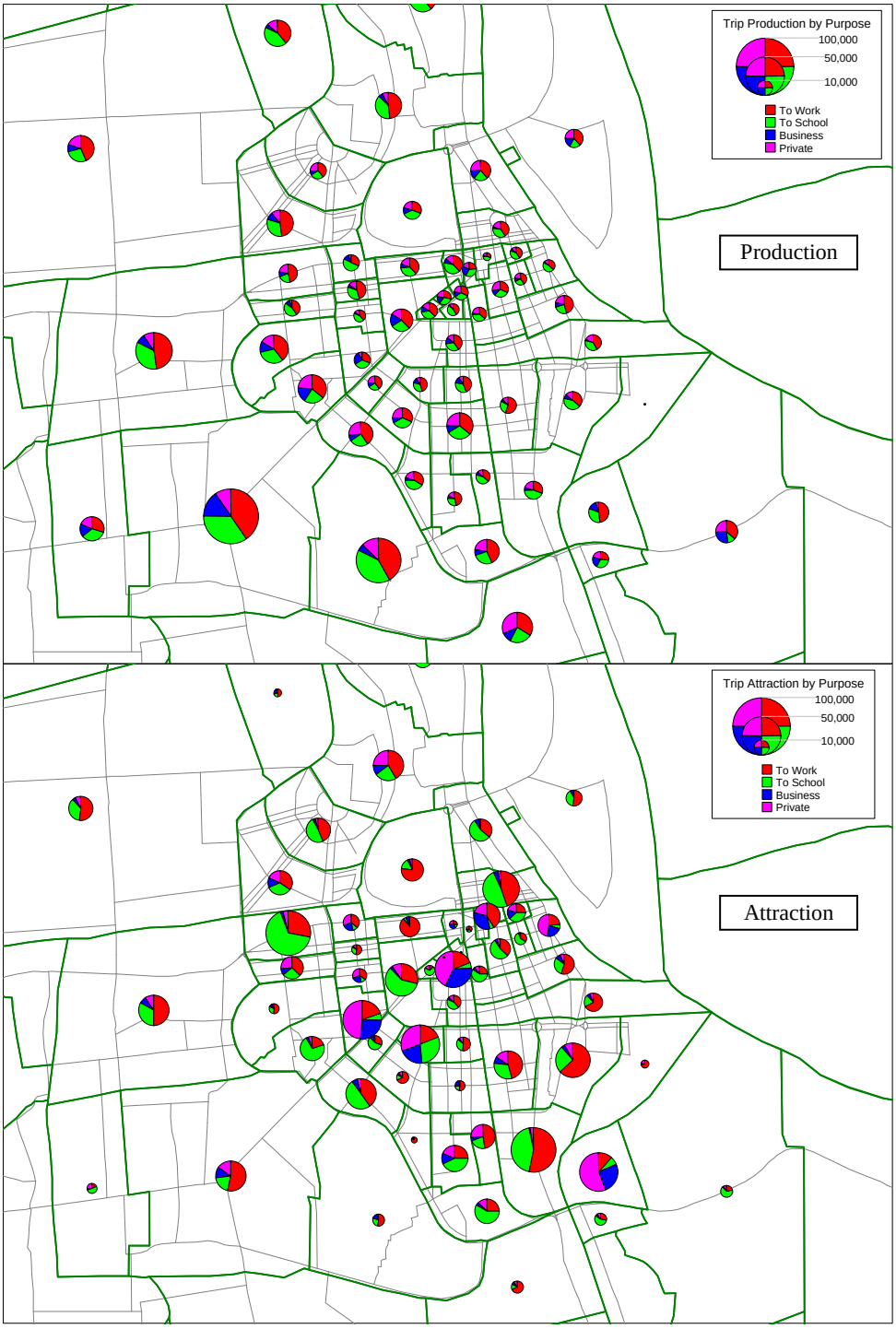
The estimated trip productions and attractions by TAZ are shown in Figure 5.2-2 for the whole Project area and in Figure 5.2-3 for the central area. A number of trips are often generated in the south-west populated suburban areas such as Stueng Mean Chey (TAZ= 70), Boeng Tumpun (71), and Chaom Chau (59), followed by Tuek L'ak (38) and Tuek Thla (93) in western part of the Project area, which have 60 thousand trips per day.

On the contrary, a number of trips are concentrated at the central area such as zones Tonle Basak (3), Olympic (7), Ou Russei (27), and Tuek L'ak (38). However, the shares by trip purpose depend on the landuse characteristics of each zone. For example, the share of commuting trips indicates a higher rate in zones such as Tonle Basak (2, 3) and Chakto Mukh (21) along Norodom, and in zones such as Srah Chak (24) and Mittakpheap (32) along Russian. The attraction of "to school" trips is high in zones Boeng Reang (18), Veal Vong (33), Phasar Daeum Thkov (14), and Boeng Salang (44), and the attraction of private purpose trips is high in zones Phasar Kandal (19), Ou Ruessei (27), Phsar Daeum Kor (43), and Chhbar Ampov (74), where large markets exist.



Source: PPUTMP Project Team

Figure 5.2-2 Trip Productions and Attractions by Purpose (Project Area)



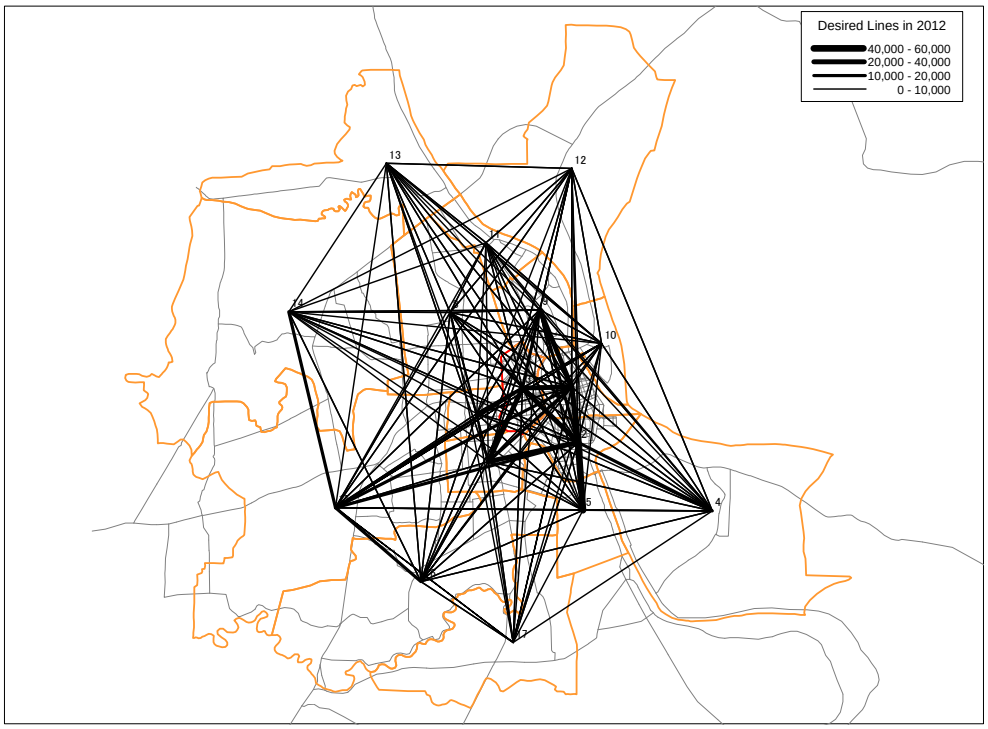
Source: PPUTMP Project Team

Figure 5.2-3 Trip Productions and Attractions by Purpose (Central Area)

5.2.5 Distribution and Travel Time

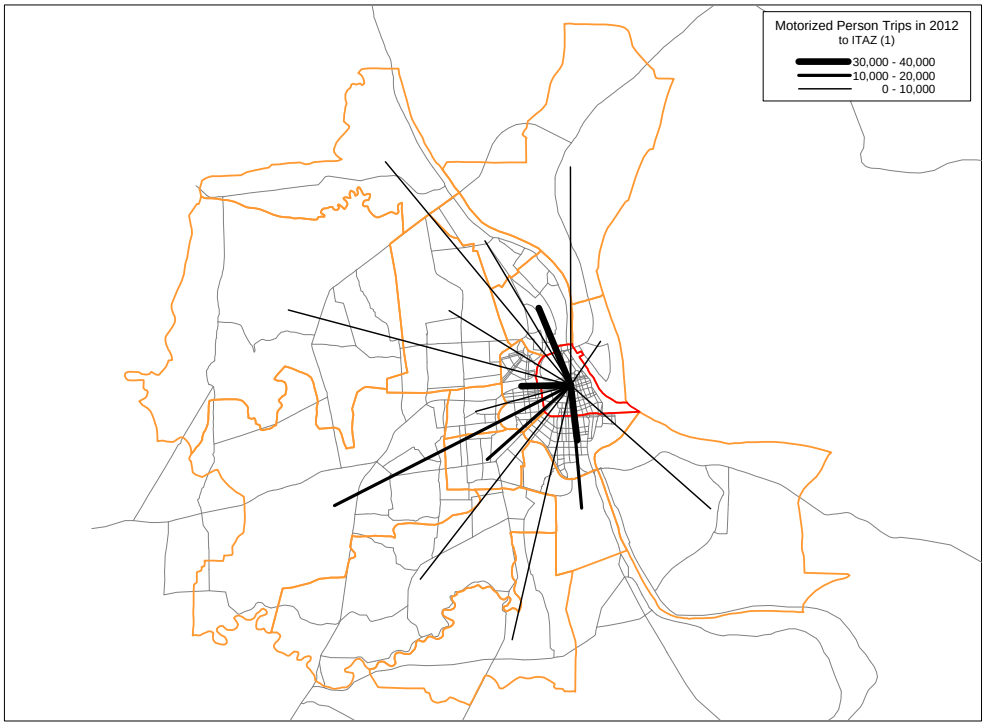
After discussing at which zones trips are produced and attracted, in this section, an analysis is made of where trips travel from and to. Figure 5.2-4 illustrates the person trip flows between integrated zones by showing the volume of trips, but excluding walking trips, with bands of varying widths.

Heavy flows, as can be seen from the figure, are between northern and southern zones such as from Russey Kaev and Camko City through Doun Penh and Prampir Meakkara, Chamkar Mon to Boeng Tumpun and Chak Angrae, and between central and western zones such as from Toul Kouk to Stueng Mean Chey or Tuek Thla. The motorized person trips to three integrated zones in the central area are exhibited in Figure 5.2-5, Figure 5.2-6, and Figure 5.2-7, respectively.



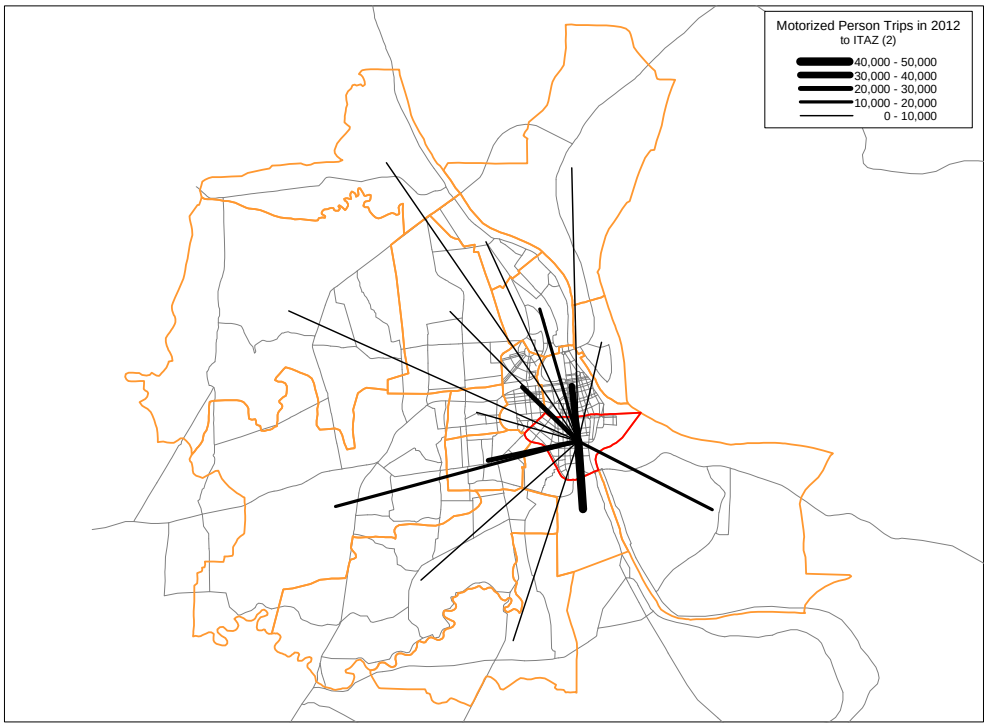
Source: PPUTMP Project Team

Figure 5.2-4 Trip Distribution by Integrated Zones



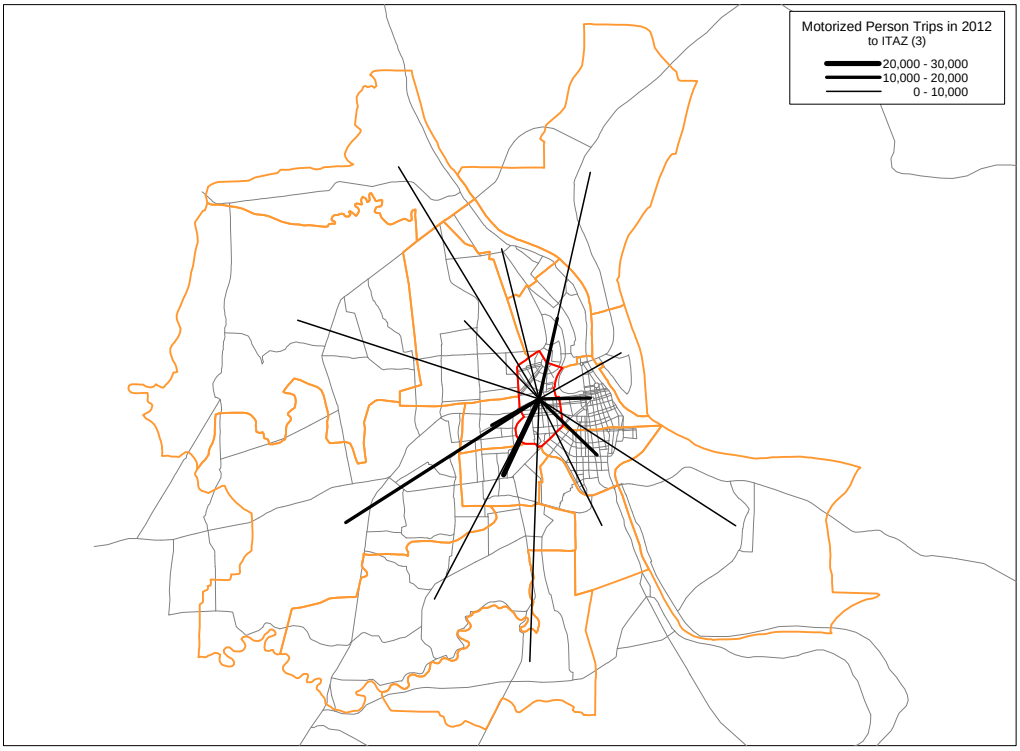
Source: PPUTMP Project Team

Figure 5.2-5 Motorized Trips to Integrated Zone 1



Source: PPUTMP Project Team

Figure 5.2-6 Motorized Trips to Integrated Zone 2



Source: PPUTMP Project Team

Figure 5.2-7 Motorized Trips to Integrated Zone 3

Next, an attempt is made to see how long, in terms of distance and time, trip makers travel. The following table summarizes average travel distance that is measured between zones on a road network, and average travel time that is calculated based on the HIS results. As shown in the table, there is no significant difference in average travel speed between the motorbike, passenger car, and para-transit, which indicates 13 km/h. Generally, cars can be driven faster than motorbikes and para-transit, but in mixed traffic, cars and motorbikes tend to slow down each other's travel speed. There is a slight difference in the average trip length by transport mode, i.e., passenger cars are used for longer trips, and para-transit, for shorter trips.

Table 5.2-9 Trip Length and Travel Time by Mode

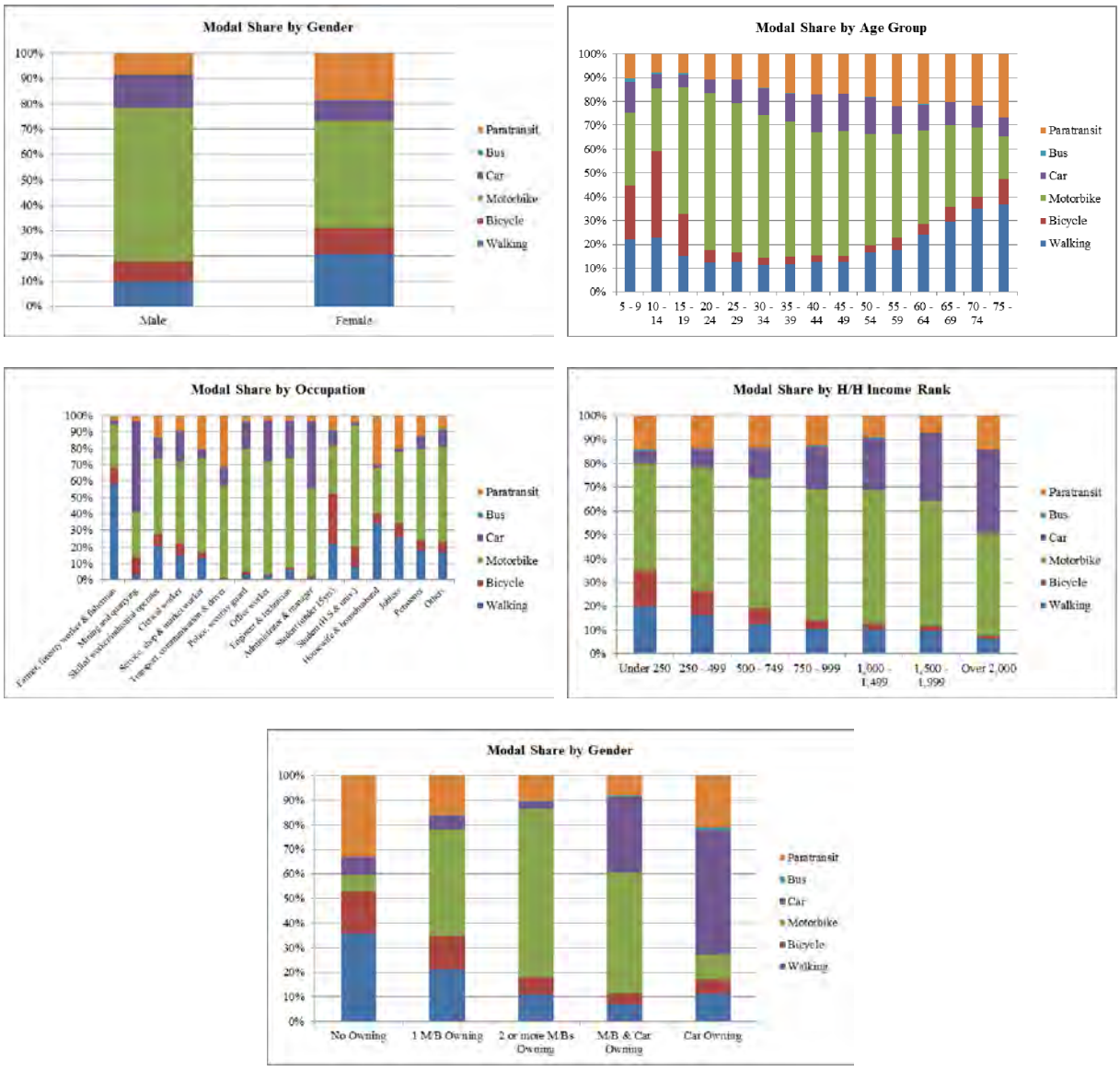
Mode	Average Trip Length (km)	Average Travel Time (min.)	Average Travel Speed (km/h)
Motorbike	5.4	23.7	13.6
Car	6.4	29.5	13.0
Para-transit	4.6	21.5	12.9
Total	***5.2***	***23.6***	***13.1***

Source: PPUTMP Project Team

5.2.6 Modal Share

Figure 5.2-8 shows modal shares by individual attribute. There is no surprise in the features of the modal shares, as seen in the figure, because these are very common tendencies in other countries and cities. For example, a para-transit-dependent population is often composed of non-vehicle-owning households; members of car-owning households have a high tendency to use passenger cars; and bicycle use is higher for younger age groups than older ones.

A remarkable feature is that there is significantly different tendency between male and female. The share of motorbikes for male indicates 60% and para-transit share is lower, while that of female is about 40% and the share of para-transit is higher. This might be caused by the cultural and physical reason that women do not drive.



Source: PPUTMP Project Team

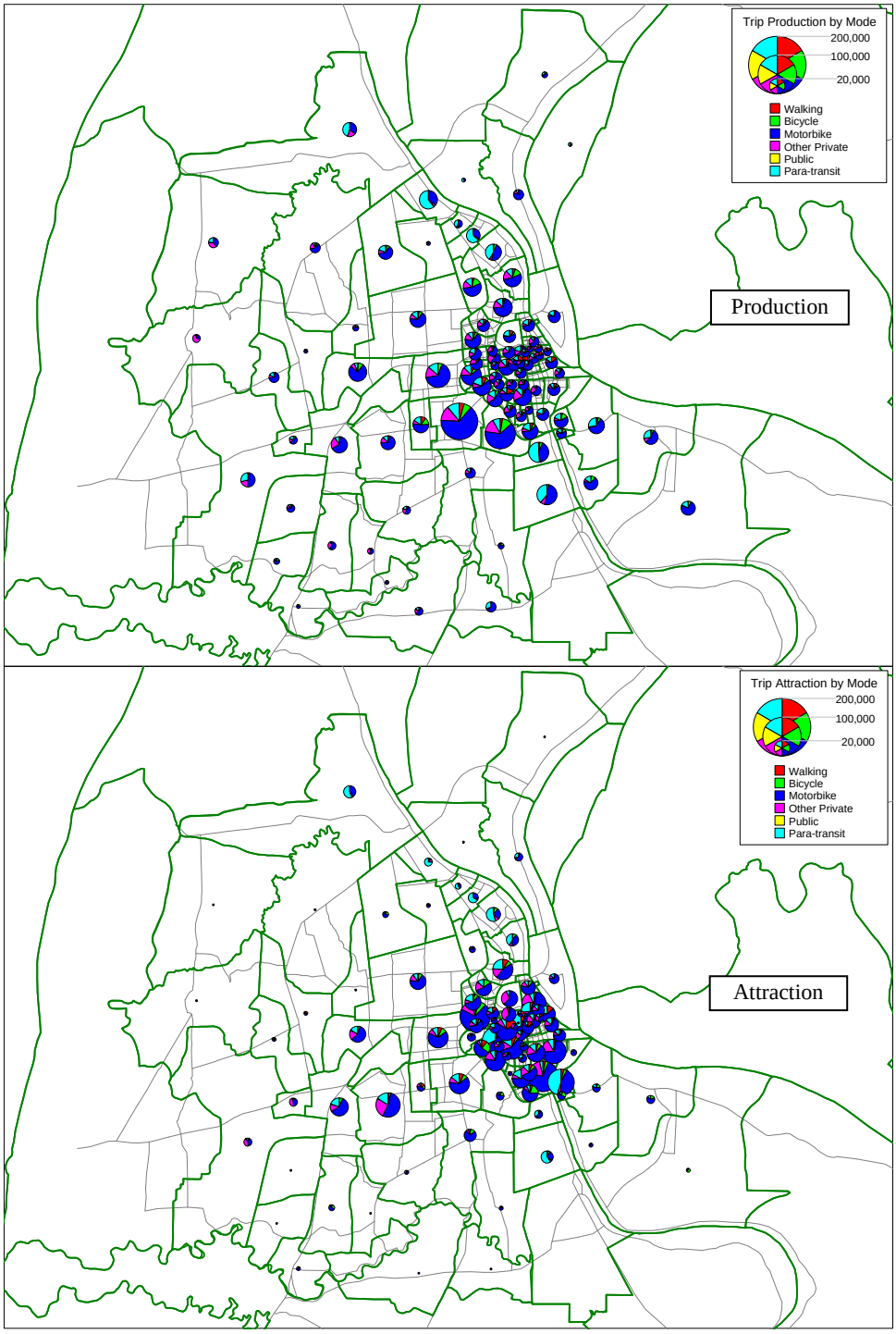
Figure 5.2-8 Modal Shares by Individual Attribute

The trip productions and attractions by transport mode are shown in Figure 5.2-9 for the whole Project area and in Figure 5.2-10 for the central area. The share of para-transit for trip production can be high in zones such as Kilometer Lekh Prammuoy (TAZ= 82), Ruessei Kaev (83), and Preaek Lieb (84) along NR5, and in zones such as Preaek Ta Sek (78) and Chrouy Changvar (79) along NR1.

On the other hand, modal shares for trip attractions have a distinctive feature in the central area by zone. For example, the share of motorbikes in zones Tonle Basak (2 and 3), Boeng Reang (18), and Chakto Mukh (21) is higher, while the share of passenger cars is high in zones Tonle Basak (3), Boeng Trabaek (13), and Mittakpheap (32). The share of para-transit is high in zones where there is a large

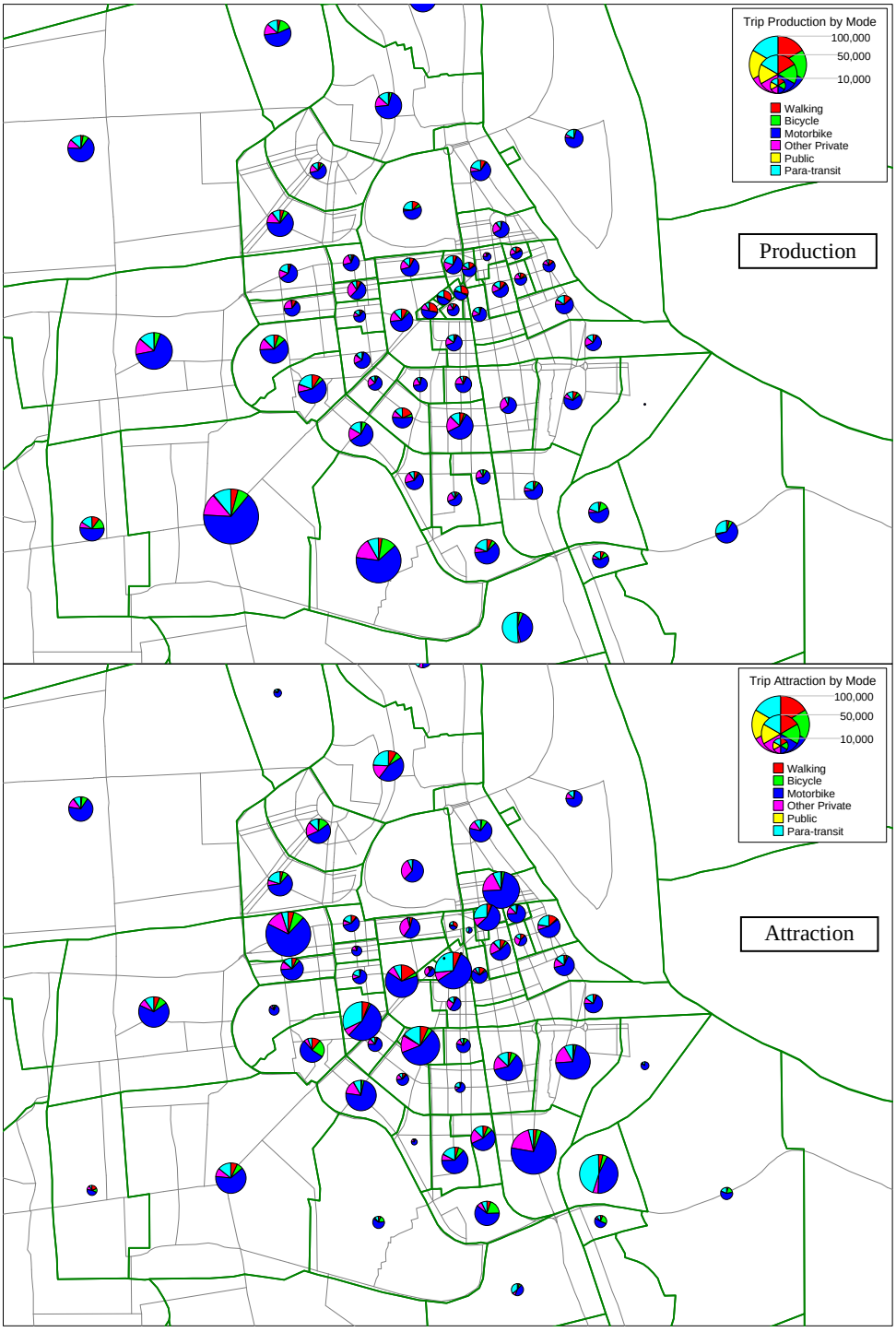
market such as Phsar Thmei (15), Phsar Kandal (19), Ou Ruessei (27), and Phsar Daeum Kor (43).

Figure 5.2-11 displays trip length distribution by mode and vehicle ownership.



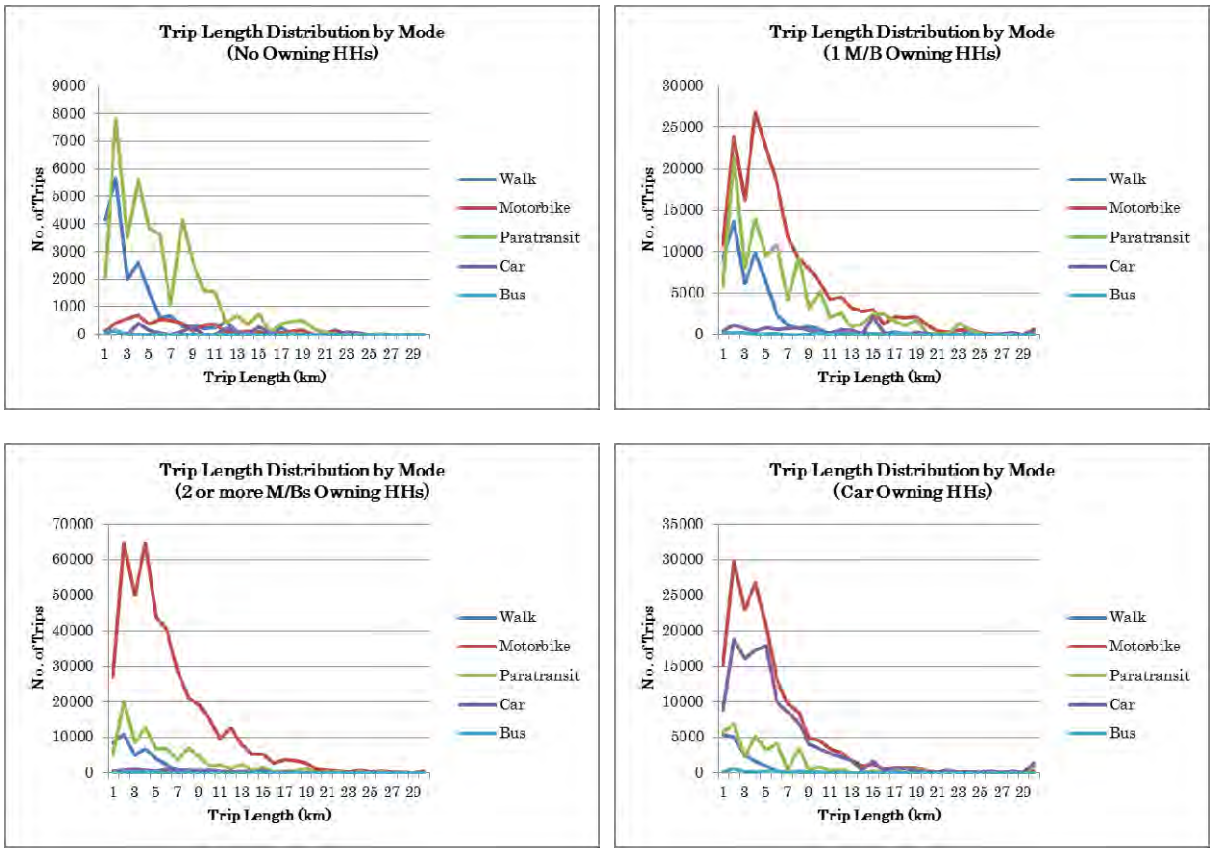
Source: PPUTMP Project Team

Figure 5.2-9 Trip Productions and Attractions by Mode (Project Area)



Source: PPUTMP Project Team

Figure 5.2-10 Trip Productions and Attractions by Mode (Central Area)



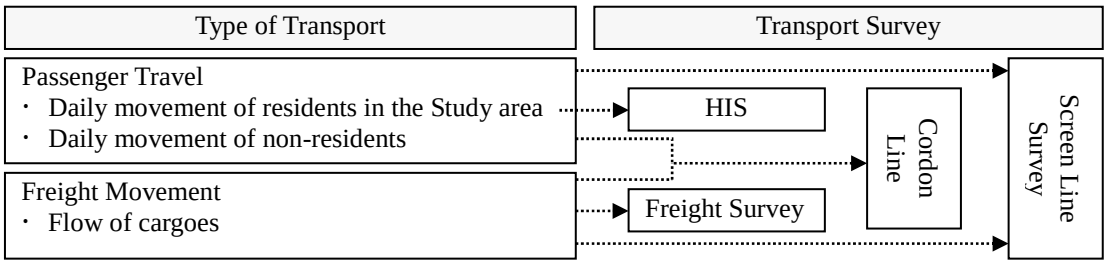
Source: PPUTMP Project Team

Figure 5.2-11 Trip Length Distribution by Vehicle Ownership

5.3 Development of Forecasting Models

The transport demand that takes place and has an influence on the level of service of the transport infrastructure in a city can be divided into passenger travel and freight movement. The passenger travel is also grouped into two: trips by residents of the Project area and trips by residents from outside the Project area. The following figure shows these demands (passenger and freight) and the surveys conducted in this project to cover the demands. These demands vary in subject and in their characteristics such as in modal share and origin and destination. Therefore, there should be a separate way of analysis and processes for model development according to the subject of the demand.

In this section and the contiguous sections, the model development and demand forecasting will be focused for passenger trips of both residents from the Project area and from outside the Project area. The trips traveled by the residents can be obtained from the HIS results and those by the non-residents can be obtained by the interview survey at Cordon Line Survey, which was conducted at the defined boundaries of the Project area to grasp the volume of vehicular traffic crossing said boundaries.



Source: PPUTMP Project Team

Figure 5.3-1 Type of Transport and Surveys for Demand Forecasting

Passenger trips of both residents and non-residents will be summarized into a table that will ultimately show the volume of transportation between two areas, the origin and the destination, thus it is called OD table. The results of the interview survey are processed in order to obtain present OD tables as mentioned above, and the major task in transport demand processes is to estimate the future OD tables based on the present OD tables.

The future OD table for the residents will be estimated by the four-step methodology, as mentioned earlier, and the future OD table for the non-residents will be estimated with a more simple approach. Both future OD tables and an OD table for cargo movement, which is discussed in another section, will be compiled and accumulated by transport mode and loaded on a network so that traffic volume by each network section can be obtained. These procedures will be detailed in this section.

5.3.1 Network Development

A key factor for transport demand forecasting is a transport network. A transport network represents the transportation system of the Project area and consists of a road network and a public transport network. However, in this project area, a public transport system such as railways and urban bus systems does not exist; therefore, when transport network is mentioned here, it means road network.

A transport network is developed for traffic situation representation in a computer, so the network should incorporate the present level of infrastructure as a physical supply of service and show the same traffic situation as it exists on the field.

Generally, by using a Geographic Information System (GIS), a transport network is developed in a computer. A road section is often described by an object called polyline, and each object should have information about the transport service level. For this purpose, data such as carriageway width and number of lanes, collected and measured by the inventory survey conducted in this project, is compiled into a GIS network database, and the level of service, namely capacity, is estimated by using the physical data in the database for each section.

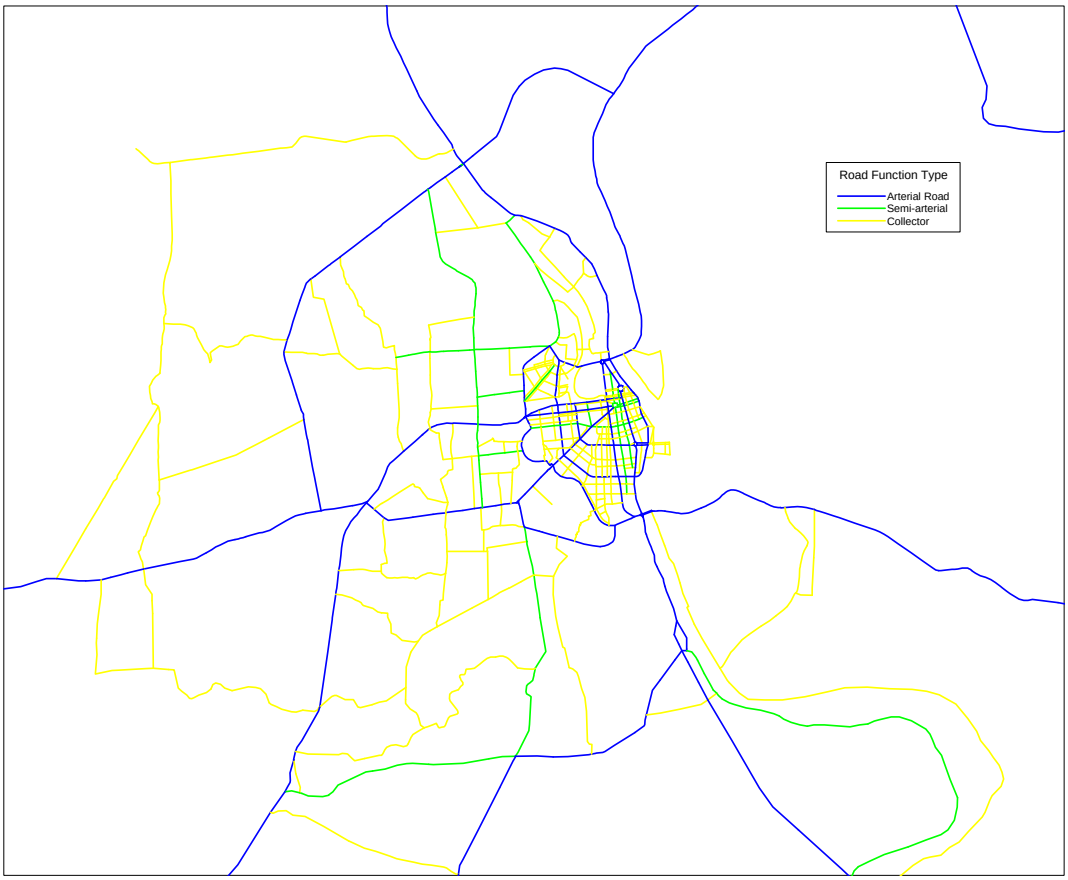
Capacity is especially important in network development. It means the maximum traffic that can pass a certain section of a road for one hour, and its value depends on the physical condition of the road section and condition of transport. When an OD table will be loaded on a network, this capacity will be used for estimating transport situations such as congestion and travel speed for each road section.

In this study, each section is classified by function, number of lanes, operation, and pavement type, among other factors, and typical capacity and travel speed, established considering these factors, are prepared for each section.

(1) GIS-Based Road Inventory

The principal information compiled in the GIS network database is as follows:

- Road Name
- Road Condition: number of lanes, carriageway width, median, width of sidewalk, pavement, etc.
- Transport Condition: Functional classification (expressway, arterial road, semi-arterial road, collector road); Decrease of capacity by parking (number of lanes); Operation (one-way or two-way); Area (urban area or suburban area); etc.



Source: PPUTMP Project Team

Figure 5.3-2 Functional Classification of Roads

(2) Capacity and Travel Speed

The capacity used in the fourth step of demand forecasting, which is traffic assignment, should be estimated in terms of the maximum daily traffic inasmuch as the OD table that is loaded on a network in the fourth step consists of daily transport demand. Daily assignment capacity of each road section is calculated by multiplying the following capacity reduction factors with basic capacity, that is, hourly possible traffic without any interrupting factor, and considering peak ratio collected by traffic count surveys.

- Lane width
- Width of shoulders
- Roadside friction
- Large vehicle ratio

Patterns of capacity and travel speed established here by functional classification of roads are described in Table 5.3-1.

Table 5.3-1 QV Table

Classification of Road	No. of Lanes	Operation	PPCC						Suburban Area					
			Unpaved		Low Capacity		Standard		Unpaved		Low Capacity		Standard	
			Speed (km/h)	Capacity (pcu/hour)	Speed (km/h)	Capacity (pcu/hour)	Speed (km/h)	Capacity (pcu/hour)	Speed (km/h)	Capacity (pcu/hour)	Speed (km/h)	Capacity (pcu/hour)	Speed (km/h)	Capacity (pcu/hour)
Expressway	2	Two-way					100	30,200						
	4	Two-way					100	60,400						
	6	Two-way					100	90,600						
Arterial Road	2	Two-way			45	8,500	50	10,900			55	12,900	60	15,200
	2	One-way			45	16,400	50	21,000			55	24,700	60	29,300
	3	Two-way			45	24,600	50	31,600			55	37,100	60	43,900
	4	Two-way			45	32,900	50	42,100			55	49,500	60	58,600
	5	Two-way			45	41,100	50	52,600			55	61,900	60	73,200
	6	Two-way			45	49,300	50	63,200			55	74,300	60	87,900
	7	Two-way			45	57,600	50	73,700			55	86,700	60	102,500
Semi-Arterial Road	2	Two-way			35	5,200	40	7,500	10	4,350	45	8,700	50	11,600
	2	One-way			35	10,100	40	14,500	10	8,400	45	16,800	50	22,200
	3	Two-way			35	15,200	40	21,800			45	25,200	50	33,400
	4	Two-way			35	20,200	40	29,100			45	33,600	50	44,500
	5	Two-way			35	25,300	40	36,300					50	55,600
	6	Two-way					40	43,600					50	66,800
Collector Road	1	One-way	10	100	25	200	30	800	10	100	35	200	40	800
	2	Two-way	10	1,950	25	3,900	30	5,300	10	3,850	35	7,200	40	9,000
	2	One-way			25	7,600	30	10,200			35	14,000	40	17,400
	3	Two-way			25	11,400	30	15,300			35	21,000	40	26,100
	4	Two-way			25	15,200	30	20,500			35	28,000	40	34,900
	5	Two-way			25	19,000	30	25,600			35	35,000	40	43,600
	6	Two-way			25	22,800	30	30,700			35	42,000	40	52,300

Source: PPUTMP Project Team

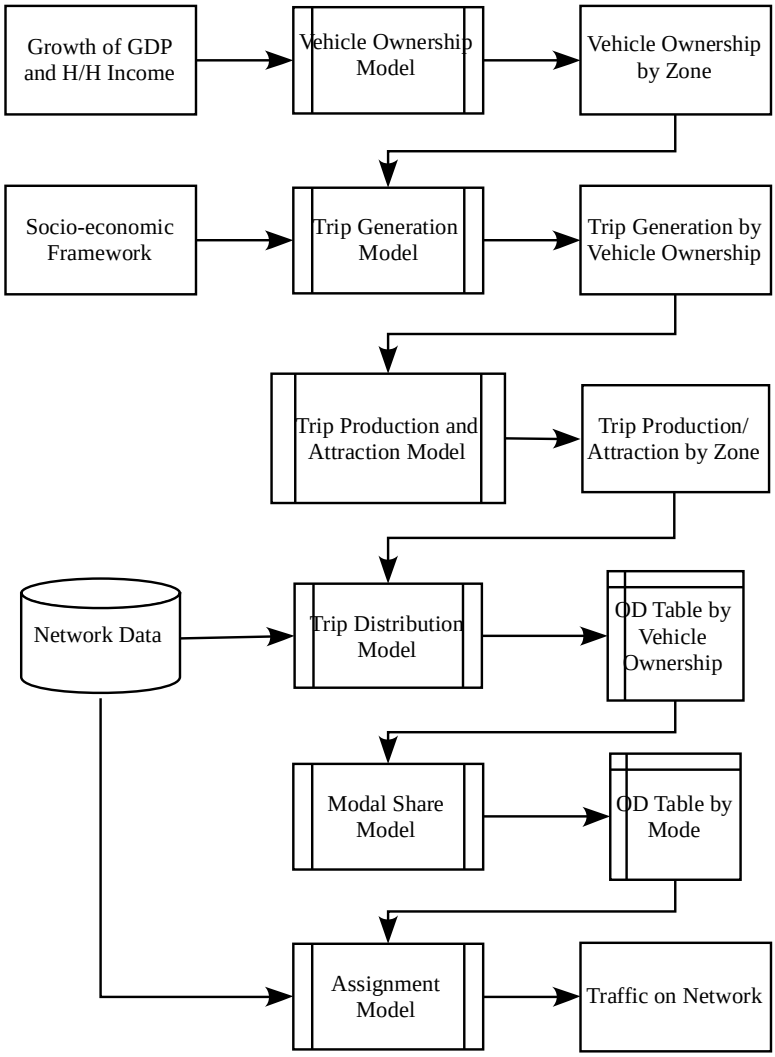
5.3.2 Travel Demand Forecasting

As stated previously, a methodology to estimate the future OD table based on the present OD table is discussed in this section. Basically, the traditional four-step methodology consisting of (1) trip production and attraction estimation, (2) trip distribution estimation, (3) modal share estimation, and (4) traffic assignment is applied for demand forecasting.

Furthermore, model development policies are established, considering the following issues found in present situation analysis:

- Transportation characteristics are distinct by individual attribute. Specially, travel mode depends on whether a household owns a passenger-car or not. Therefore, forecasting models should be developed by vehicle ownership level.
- There is no urban public transport system in this city so that modal choice depends on not destination of travel but vehicle ownership. Therefore, a trip-end model that decides mode choice when leaving home is employed.

Based on these policies, a flow of procedures for demand forecasting is shown in the following figure. First, the future population established by the previous chapter is distributed into four groups of vehicle ownership, namely, no vehicles owned, owning one motorbike, owning two or more motorbikes, and car-owning, with a model forecasting. This will be carried out by inputting household income in the future into models that are developed through analysis of the relationship between vehicle ownership rate and household income. Next, trip productions and attractions will be estimated by TAZ and the four groups with the distributed population; and then trip distribution will be forecasted to make an OD table by trip purpose. Finally, the OD table by trip purpose and vehicle ownership group will be distributed into trips by mode: walking, motorbike, passenger car, and para-transit. The OD tables by mode will be distributed on a transport network so that future transport demand on the network can be given. The following figure illustrates the procedure.



Source: PPUTMP Project Team

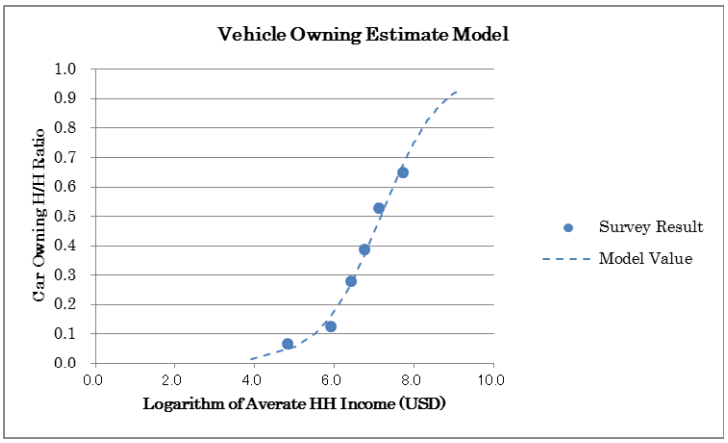
Figure 5.3-3 Travel Demand Forecasting Procedure

(1) Vehicle Ownership Models

Vehicle ownership models are used to estimate the share of households by vehicle ownership. Three models are developed, namely, the ratio of passenger-car-owning households to the total number of households, the ratio of two-or-more-motorbike-owning households to the total number of households that do not own a passenger car, and the ratio of one-motorbike-owning households to the rest.

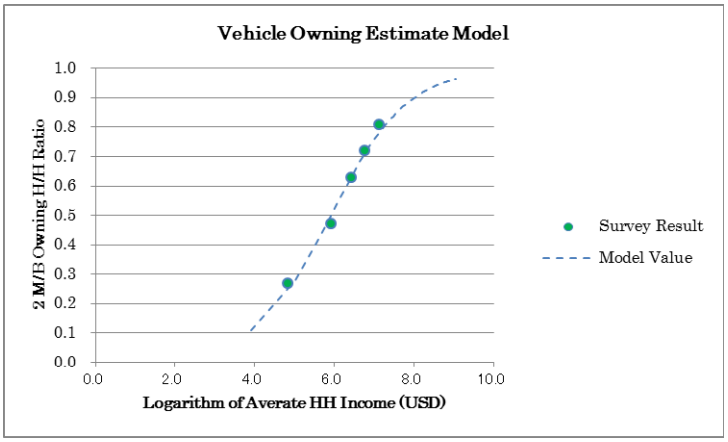
$$P_C = \frac{1.0}{1+e^{9.431-1.318\cdot\ln(X)}}$$

Where, P_C : Passenger car ownership
X : Household income (USD)
(correlation coefficient=0.992)



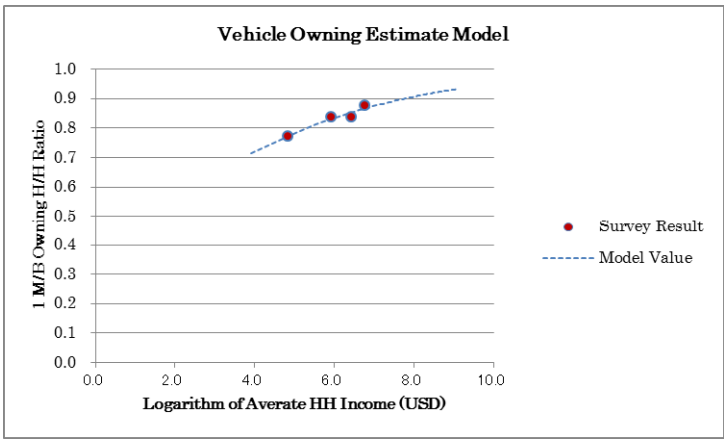
$$P_{1MB} = \frac{1.0}{1+e^{6.210-1.051\cdot\ln(X)}}$$

Where, P_{1MB} : Ownership of two or more motorbikes
X : Household income (USD)
(correlation coefficient=0.994)



$$P_{2MB} = \frac{1.0}{1+e^{0.370-0.331\cdot\ln(X)}}$$

Where, P_{2MB} : Ownership of one motorbike
X : Household income (USD)
(correlation coefficient=0.958)



Source: PPUTMP Project Team

Figure 5.3-4 Vehicle Ownership Estimation Models

(2) Trip Generation

The trip generation is aimed at calculating the total number of trips that is produced by the population in the Project area per day. In this project, the trip rates shown in the following tables are employed for the calculation so that the total number can be obtained by vehicle ownership and travel purpose.

Table 5.3-2 Trip Rates by Vehicle Ownership

Vehicle Ownership	No. of HHs ('000)	Population ('000)	Population aged over 5 yrs. ('000)	No. of Trip Makers	Trip-maker Ratio (%)	No. of Trips ('000)	Trip Rate (Gross)	Trip Rate (Net)
No vehicles owned	29.3	134.5	124.9	99.1	79.4	289.5	2.32	2.92
1 M/B	131.4	612.0	563.0	459.4	81.6	1,333.8	2.37	2.90
2 or more M/Bs	145.7	749.3	697.6	587.3	84.2	1,732.2	2.48	2.95
Car	69.3	356.3	326.6	271.5	83.1	939.3	2.88	3.46
Total	***375.7***	***1,852.0***	***1,712.1***	***1,417.3***	***82.8***	***4,294.8***	***2.51***	***3.03***

Source: PPUTMP Project Team

Table 5.3-3 Trip Rates by Vehicle Ownership and Travel Purpose

Vehicle Ownership	To Home	To Work	To School	Business	Private	Total
No vehicles owned	1.07	0.44	0.27	0.16	0.22	2.15
1 M/B	1.07	0.41	0.32	0.13	0.26	2.18
2 or more M/Bs	1.14	0.46	0.34	0.12	0.26	2.31
Car	1.29	0.56	0.39	0.10	0.29	2.64
Total	***1.14***	***0.46***	***0.33***	***0.12***	***0.26***	***2.32***

Source: PPUTMP Project Team

(3) Trip Production and Attraction

Next, demand forecasting estimates trip production, i.e., number of trips produced from a zone, and trip attraction, i.e., number of trips attracted to a zone. Trip production is calculated by multiplying the trip rate with the population of each zone, and trip attraction is estimated by models developed by analyzing the relationship between present zonal attraction and socio-economic situation by TAZ. After trip productions and attractions are estimated, a number of intra-zonal trips produced in and attracted to the same zone will be estimated by using the trip productions and attractions. For the calculation of intra-zonal trips, the following present ratio is employed.

Intra-zonal Trip Ratio:

$$R_i = \frac{T_{ii}}{\min(P_i, A_i)}$$

Where, R_i : Intra-zonal trip ratio of i zone

T_{ii} : Number of intra-zonal trips of i zone at the present time

P_i : Trip production of i zone at present

A_i : Trip attraction of i zone at present

Trip Attraction Model:

$$A_j = \alpha \cdot P_j + \beta \cdot E_j + \gamma \cdot S_j + \delta \cdot d_j + c$$

Where, A_j : Trip attraction of j zone

P_j : Population of j zone by vehicle ownership

E_j : Number of employees of j zone

S_j : Enrolment of j zone

d_j : Dummy variable

$\alpha, \beta, \gamma, \delta$: Parameters of model (refer to Table 5.3-4)

Table 5.3-4 Parameters of Trip Attraction Model

Vehicle Ownership	Purpose	Constant	Population	Employment	Enrolment	Dummy	Correlation Coefficient
No vehicles owned	To Work	78.7	0.0150	0.0323		2176.6	0.825
	To School	54.3	0.0113		0.0239	2008.9	0.835
	Business	0.0	0.0108	0.0043		1049.3	0.813
	Private	0.0	0.0087	0.0178		1589.2	0.873
1 M/B	To Work	64.0	0.0726	0.1798		6376.6	0.907
	To School	378.4	0.0527		0.1800	0.0	0.801
	Business	2.9	0.0259	0.0276		4260.4	0.861
	Private	0.0	0.0614	0.0661		6217.8	0.901
2 or more M/Bs	To Work	758.1	0.0522	0.2700		8099.6	0.882
	To School	633.0	0.0472		0.2263	14138.6	0.786
	Business	108.7	0.0202	0.0307		5338.4	0.866
	Private	76.6	0.0436	0.1356		9496.0	0.890
Car	To Work	434.9	0.0421	0.1343		6718.4	0.646
	To School	197.3	0.0378		0.0959	4948.6	0.765
	Business	27.6	0.0069	0.0113		2695.2	0.869
	Private	281.4	0.0089	0.0707		3713.9	0.808

Source: PPUTMP Project Team

(4) Trip Distribution

The next step of travel demand estimation in the traditional approach is trip distribution. This step is generally done after trip production and attraction estimations are completed and trip productions are distributed to various destination zones. The most popular model for trip distribution is the Gravity Model, which is adopted from Newton's gravitational law of physics. In this project, this model is employed as follows:

Gravity Model:

$$Tij = K \cdot \frac{P_i^{\alpha} A_j^{\beta}}{d_{ij}^{\gamma}}$$

Where, T_{ij} : Trip distribution between i zone and j zone

P_i : Trip production of i zone

A_j : Trip attraction of j zone

d_{ij} : Impedance between i zone and j zone

α, β, γ : Parameters of model (refer to Table 5.3-5)

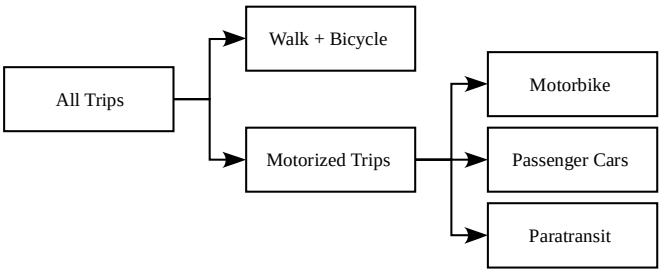
Table 5.3-5 Parameters of Trip Distribution Models

Vehicle Ownership	Purpose	K	α	β	γ	Correlation Coefficient
No vehicles owned	To Work	30.8	0.1812	0.1763	-0.5546	0.542
	To School	0.7	0.5968	0.3042	-0.4715	0.827
	Business	60.8	0.0448	0.2319	-0.5966	0.767
	Private	1.5	0.3710	0.4306	-0.5133	0.764
1 M/B	To Work	42.4	0.2087	0.1978	-1.0202	0.639
	To School	68.8	0.2479	0.1329	-1.1701	0.837
	Business	16.4	0.3008	0.1669	-0.5990	0.715
	Private	7.1	0.3029	0.3054	-0.8364	0.778
2 or more M/Bs	To Work	25.1	0.2902	0.2137	-1.0564	0.820
	To School	3.5	0.5023	0.1979	-0.8939	0.863
	Business	12.1	0.4645	0.0792	-0.5861	0.829
	Private	3.9	0.4525	0.2385	-0.7032	0.816
Car	To Work	27.1	0.2266	0.2030	-0.8088	0.793
	To School	21.7	0.2968	0.1988	-1.0192	0.854
	Business	12.1	0.3365	0.1217	-0.3110	0.775
	Private	29.4	0.1865	0.1890	-0.5980	0.803

Source: PPUTMP Project Team

(5) Modal Share Model

The third step of the approach is modal choice, which is typically performed after trip distribution estimation. Specially, each of the inter-zonal trips that are in the OD table as elements will be split to various alternative modes such as walking, motorbikes, passenger cars, and para-transit. The process of splitting is carried in two steps as shown in the following figure.



Source: PPUTMP Project Team

Figure 5.3-5 Structure of Modal Choice

The model that splits all trips into two modes, namely, trips by walking and bicycle and trips by motor vehicle, is a formula developed by the analysis of the relationship between walking trip rate and travel distance measured on the present network.

Walk Trip Share Model:

$$P_{ij}^{Walk} = \frac{1}{1+e^{(\alpha \cdot d_{ij} + \beta)}}$$

Where, P_{ij}^{Walk} : Share of walking trips between i zone and j zone

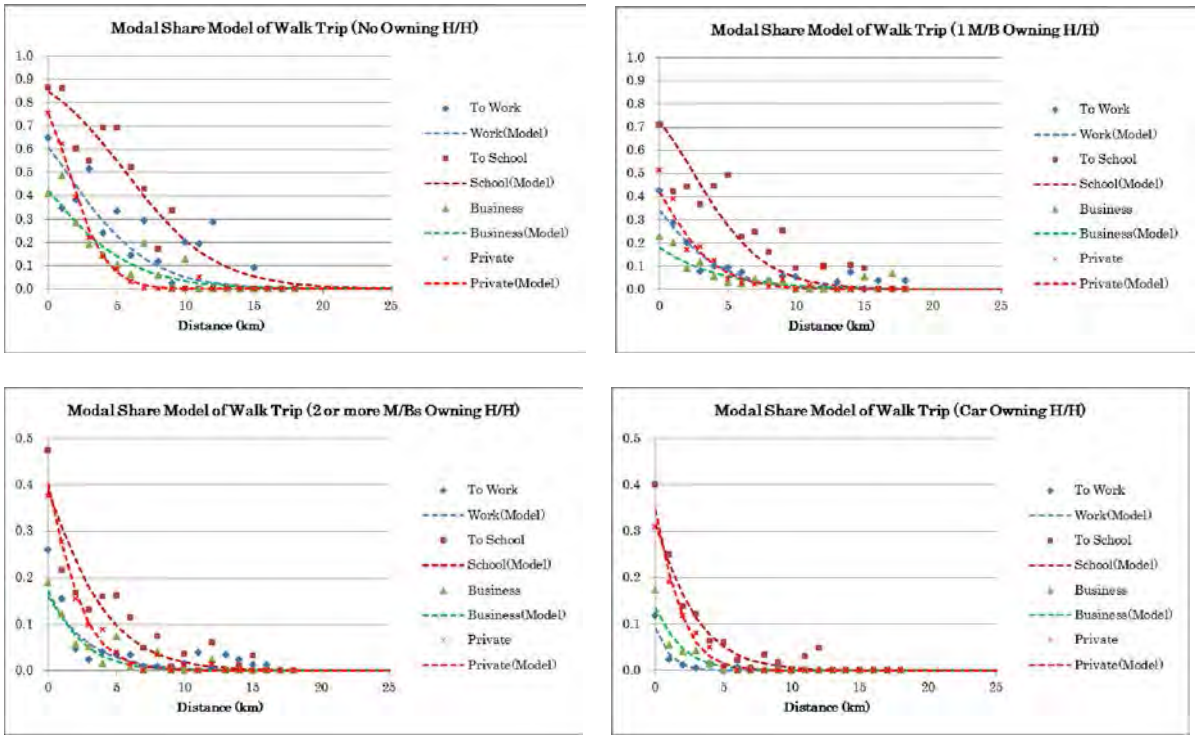
d_{ij} : Impedance between i zone and j zone

α, β, γ : Parameters of model (refer to Table 5.3-6)

Table 5.3-6 Parameters for Walk Trip Share Model

Vehicle Ownership	Purpose	α	β	Correlation Coefficient
No vehicles owned	To Work	0.3354	-0.4450	0.71
	To School	0.3067	-1.7234	0.76
	Business	0.3031	0.3069	0.74
	Private	0.7442	-1.1293	0.99
1 M/B	To Work	0.3579	0.6572	0.89
	To School	0.3915	-0.9777	0.38
	Business	0.2592	1.5239	0.76
	Private	0.4543	0.3057	0.84
2 or more M/Bs	To Work	0.3743	1.6623	0.83
	To School	0.3550	0.4581	0.76
	Business	0.4696	1.5706	0.68
	Private	0.5953	0.3962	0.96
Car	To Work	1.0397	2.2943	0.95
	To School	0.4295	0.7741	0.83
	Business	0.5708	1.8586	0.87
	Private	0.7031	0.6379	0.92

Source: PPUTMP Project Team



Source: PPUTMP Project Team

Figure 5.3-6 Walk Trip Share Model by Vehicle Ownership

Values in the following table, which is obtained as the present share of three modes, are applied to estimate the number of trips by mode for each of the inter-zonal trips. For example, if the number of trips by non-vehicle-owning households is 1,000 for “to work” purpose in total, 146 trips are by motorbike, 248 trips are by passenger car, and 605 trips are by para-transit. This share will be determined when the trip starts according to which vehicle ownership group the trip maker belongs; therefore, travel distance or destination is not a factor.

Table 5.3-7 Modal Share of Motorized Trips

Vehicle Ownership	Purpose	Motorbike	Car	Para-transit
No vehicles Owned	To Work	0.146	0.248	0.605
	To School	0.325	0.122	0.553
	Business	0.088	0.007	0.905
	Private	0.088	0.043	0.869
1 M/B	To Work	0.706	0.117	0.177
	To School	0.695	0.106	0.199
	Business	0.653	0.023	0.324
	Private	0.608	0.015	0.378
2 or more M/Bs	To Work	0.882	0.043	0.075
	To School	0.888	0.034	0.078
	Business	0.811	0.016	0.172
	Private	0.716	0.006	0.278
Car	To Work	0.417	0.563	0.020
	To School	0.775	0.161	0.065
	Business	0.495	0.363	0.142
	Private	0.547	0.162	0.291

Source: PPUTMP Project Team

5.3.3 Trips of Non-Residents

A methodology to estimate future OD table of residents outside the Project area is discussed in this section. The present OD table was constructed with the interview results, which include OD pairs of travel done by non-residents. For the estimation of the future OD table of non-residents, each of the origin-destination volume in the present OD table will be expanded with the growth rate of each zone. The formula is shown below.

Non-Residents OD Table Forecasting:

$$FOD_{ij}^{External} = EOD_{ij}^{External} \times R_i \cdot R_j$$

Where, $FOD_{ij}^{External}$: Number of trips by non-residents between i zone and j zone in the future

$EOD_{ij}^{External}$: Number of trips by non-residents between i zone and j zone at present

R_i : Growth rate of population in i zone

Table 5.3-8 Population Growth of Kandal Cities

Code	Khan	2012 Population	2035 Population	Growth Rate
0801	Kandal Stueng	90,314	134,159	1.485
0802	Kien Svay	137,108	174,497	1.273
0803	Khsach Kandal	122,181	149,884	1.227
0806	Lvea Aem	76,958	82,676	1.074
0807	Mukh Kampul	73,079	94,290	1.290
0808	Angk Snuol	93,818	154,347	1.645
0809	Ponhea Lueu	95,173	132,613	1.393
0810	S'ang	205,851	265,189	1.288
0811	Ta Khmau	89,016	139,619	1.568
Total		***983,497***	***1,327,272***	***1.350***

Source: PPUTMP Project Team

5.4 Future Transport Demand Forecasting

5.4.1 Vehicle Ownership

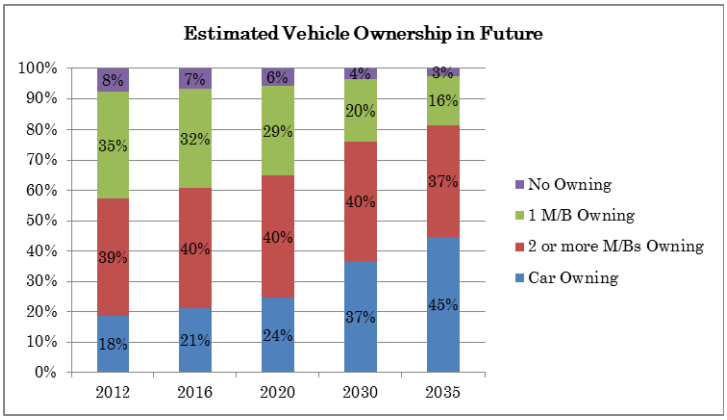
The results of the estimation of vehicle ownership by using the models developed in the previous section are summarized in Table 5.4-1 and Figure 5.4-1.

The number of car-owning households in 2012 was 69.3 thousand, or a percentage share of 18.4%. In 2035, it is estimated that this number will grow to 259 thousand, or 44.5%, which is an increase of 3.7 times. On the other hand, non-vehicle-owning households will drop to about 2%, which means almost all households will own a motorbike and/or a passenger car in the future.

Table 5.4-1 Estimates of Vehicle Ownership

Year	Population ('000)	No. of HHs ('000)	No. of HHs by Vehicle Ownership ('000)			
			Car	2 or more M/Bs	1 M/B	No vehicles owned
2012	1,852.2	375.7	69.3	145.7	131.4	29.3
2016	2,147.4	435.5	91.8	173.2	140.4	30.1
2020	2,405.5	487.9	119.4	197.5	141.9	29.1
2030	2,772.0	562.2	206.0	222.5	113.3	20.4
2035	2,867.6	581.6	259.0	215.6	91.7	15.3

Source: PPUTMP Project Team



Source: PPUTMP Project Team

Figure 5.4-1 Change in Vehicle Ownership in the Future

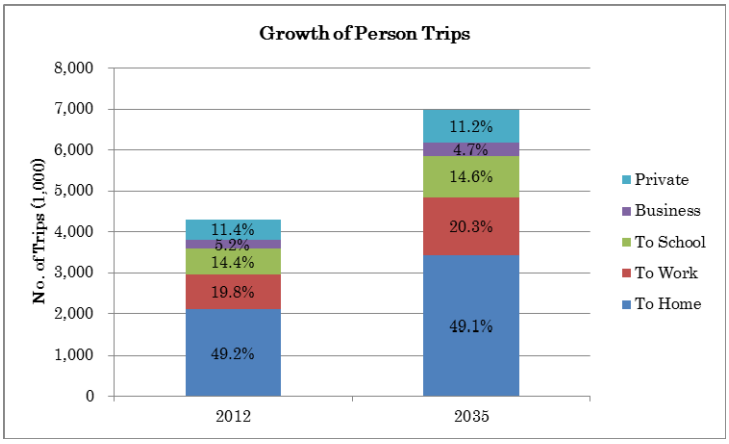
5.4.2 Future Trip Generation

The future trip generation, defined as total number of trips produced in the Project area, can be estimated by vehicle ownership and travel purpose by multiplying the population and trip rate as shown in Table 5.4-2. In total, the number of trips generated is estimated at 6,971.7 thousand trips corresponding to the population of 2,867.6 thousand in 2035. The increase in trips from 2012 to 2035 is about 2.7 million, which is 1.6 times that in 2012.

Table 5.4-2 Estimated Number of Trips Generated by Residents

Vehicle Ownership	Population ('000)	Number of Trips by Purpose ('000 trips)					
		To Home	To Work	To School	Business	Private	Total
No vehicles owned	75.3	80.4	33.3	20.1	11.8	16.6	162.2
1 M/B	452.1	485.2	183.2	142.8	57.7	116.3	985.2
2 or more M/Bs	1,063.2	1,207.8	488.9	356.9	125.2	279.1	2,457.8
Car	1,277.1	1,649.9	711.3	500.6	132.8	371.9	3,366.5
Total	***2,867.6***	***3,423.3***	***1,416.6***	***1,020.4***	***327.4***	***783.9***	***6,971.7***

Source: PPUTMP Project Team

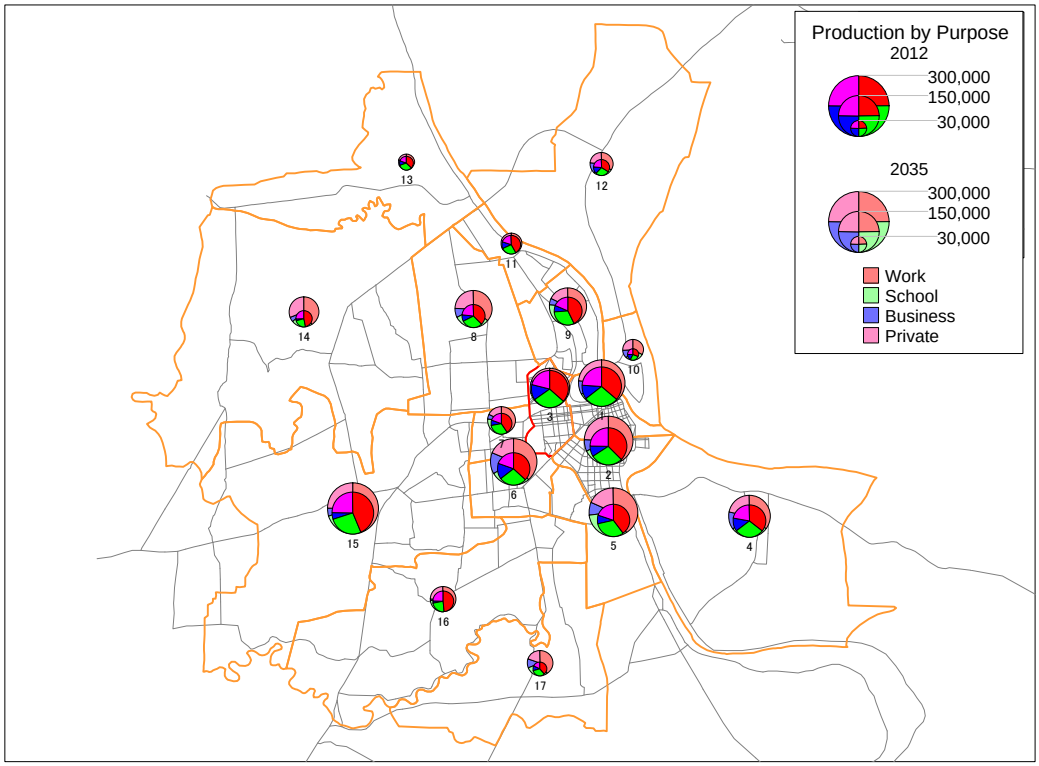


Source: PPUTMP Project Team

Figure 5.4-2 Growth of Trip Generation

Figure 5.4-3 and Figure 5.4-4 show the estimated trip productions and attractions by purpose (excluding "to home"), summarized in the integrated zones.

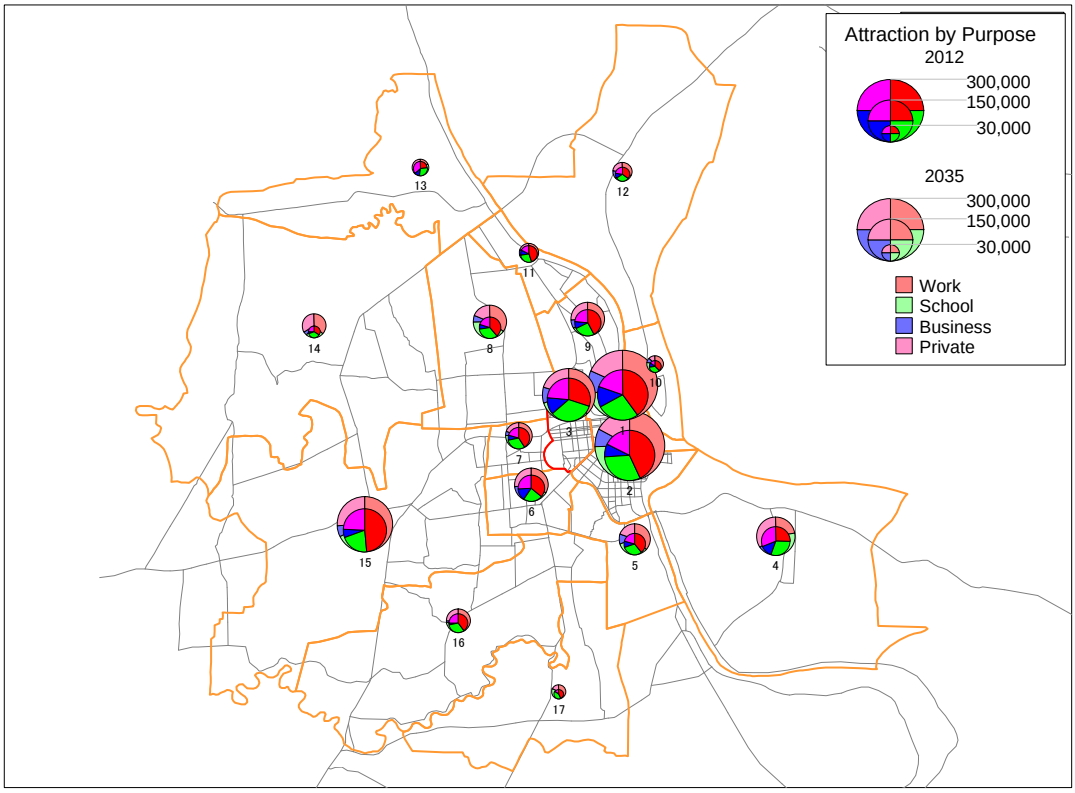
A large number of trip productions can be seen in the following zones in 2035: Doun Penh and Prampir Meakkara (Integrated Zone= 1), Chamkar Mon (2), Boeng Tumpun and Chak Angrae (5), Stueng Mean Chey (6), and Posen Chey (15). It is clear by looking at the difference between the present and future that neighboring zones of the central area such as Boeng Tumpun and Chak Angrae (5), Stueng Mean Chey (6), and Sen Sok (8), have a big increase of trip productions.



Source: PPUTMP Project Team

Figure 5.4-3 Growth of Production by Integrated Zones

On the other hand, the zones attracting a large number of trips in 2035 are concentrated in the central area of four districts, namely, Chamkar Mon, Doun Penh, Prampir Meakkara, and Toul Kouk. The trip attractions seen in these districts seem to start origin zones shown in Figure 5.4-3. The increase in trip attractions from 2012 at these four districts can be estimated at more than 600 thousand trips (excluding “to home” trips).



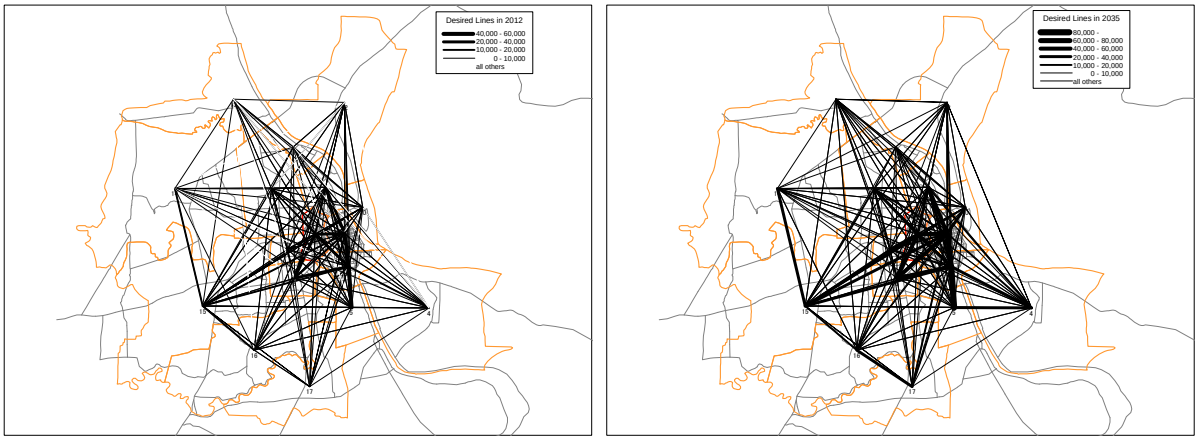
Source: PPUTMP Project Team

Figure 5.4-4 Growth of Attraction by Integrated Zones

5.4.3 Trip Distribution

Figure 5.4-5 below show trip distribution displayed between integrated zones of the present (on the left) and the future (on the right).

Trip distribution increases between all of the zones in the Project area, especially the western zones such as Stueng Mean Chey (Integrated zone= 6), Tuek Thla (7), Dang Kao (15), and the four districts in the central area; the southern zones such as Boeng Tumpun (5) and the central area are expected to have a high volume of transport demand in 2035, while trip distribution was concentrated only in the central area and its neighboring zones in 2012.



Source: PPUTMP Project Team

Figure 5.4-5 Growth of Trip Distribution by Integrated Zones

5.4.4 Modal Share

Modal share will be discussed in this section. However, mode choice by trip makers does not depend upon transport services on a route to their destination but on the vehicle ownership of the household to which they belong. This means the results of forecasting discussed in this section merely show a case based on an assumption that no comprehensive public transport is introduced, in other words, same as present situation, and socio-economic frame is enlarged.

Table 5.4-3 shows a comparison of modal shares of four representative modes between 2012 and 2035. In 2035, the number of trips by passenger car is estimated at 1,198.6 thousand, which is 17.2% of the total trips. The increase of passenger car trips from 2012 exceeds 780 thousand trips. The modal share of motorbikes indicates 55.0% in 2035, while it is 52.4% in 2012. In the case of motorbike trips, the share does not show a large increase but the increase of trips is considerable with 1,610 thousand trips, and this may be a heavy burden to traffic on the road network in the future.

Table 5.4-3 Modal Share in 2035

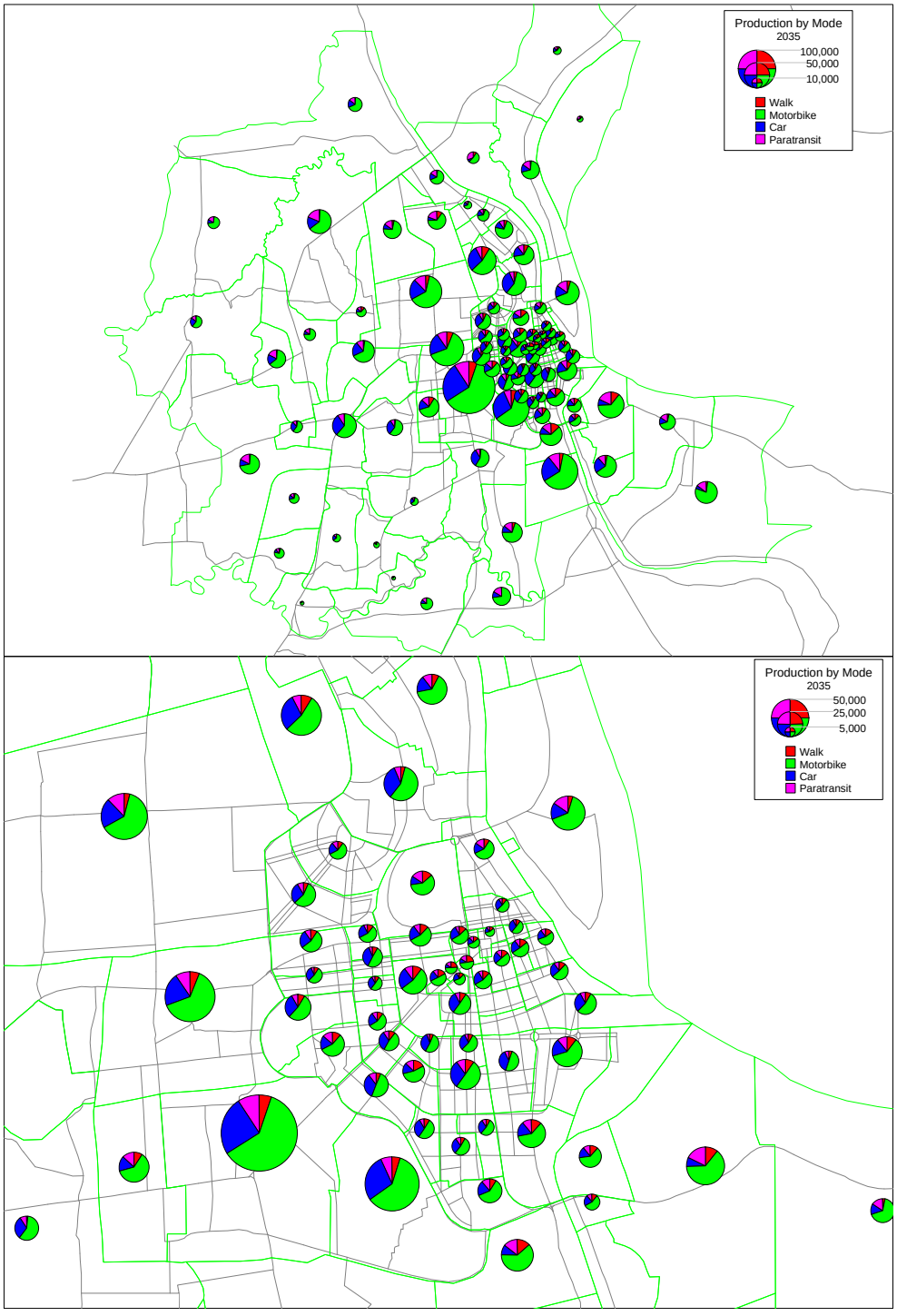
Travel Mode	2012		2035	
	Trips (‘000)	Share (%)	Trips (‘000)	Share (%)
Walk	1,031.2	24.3	1,146.5	16.4
Motorbike	2,223.5	52.4	3,834.0	55.0
Car	421.6	9.9	1,198.6	17.2
Para-transit	570.5	13.4	792.6	11.4
Total	***4,246.8***	***100.0***	***6,971.7***	***100.0***

Source: PPUTMP Project Team

The number of trips by these modes is displayed by zone in Figure 5.4-6 and Figure 5.4-7 in order to identify where trips by mode are generated and concentrated.

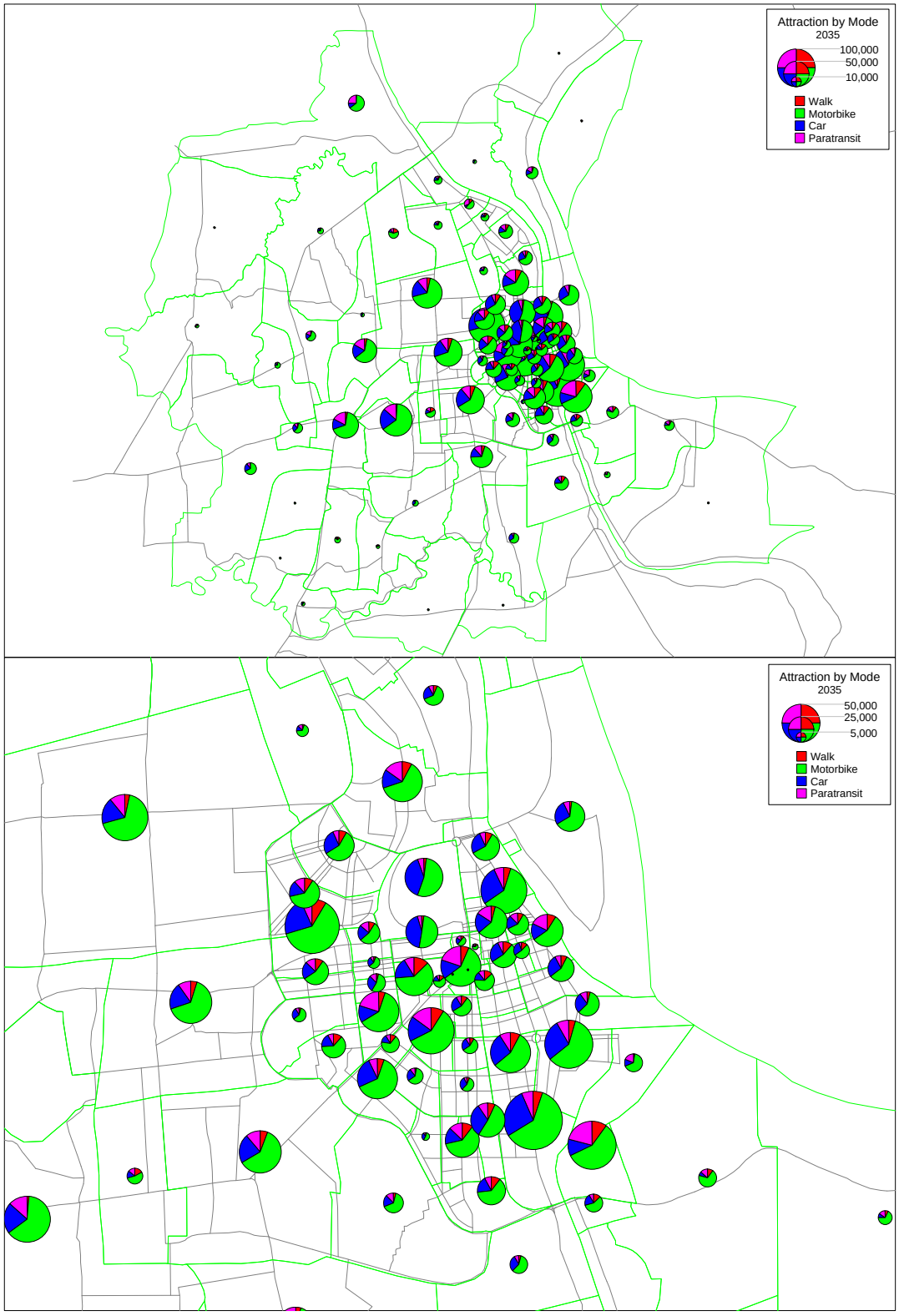
A large number of trips by passenger car generates from neighboring zones of the central area such as Stueng Mean Chey, whose total trips are very large because of the population and the size of the zones. In the central area, Boeng Keng Kang (TAZ= 6), Tumnob Tuek (10), and Veal Vong (33) have huge productions of trips by passenger car.

The zones along major roads, namely, Tonle Basak (3), Boeng Keng Kang (4, 6), and Boeng Trabaek (13) along Monivong, Tumnob Tuek (10) along Monireth, and Mittakpheap (32) and Tuek L’ak (38) along Russian have immense concentrations of passenger car trips in the future. And it is obvious that the trips by para-transit concentrate in zones such as Phasar Kandal (19), Ou Ruessei (27), and Phasar Daeum (43) where major markets exist.



Source: PPUTMP Project Team

Figure 5.4-6 Trip Productions by TAZ in 2035



Source: PPUTMP Project Team

Figure 5.4-7 Trip Attractions by TAZ in 2035

5.4.5 Traffic on Network

(1) General

Traffic volume can be estimated by assigning transport demand (OD tables) on a transport network as explained in the previous section. Therefore, for the traffic assignment procedure, which is the last step of the traditional approach, there are several cases according to the combinations of an OD table and a network. In this section, the following will be analyzed:

- Present Case: The present OD table will be distributed on the present network that is modeled to represent present transport condition on the field, in order to simulate an actual phenomenon on a computer. This result will be used to check the accuracy of the models and calibrate parameters of the models.
- "Do Nothing" Case: The future transport demand estimated based on the framework will be distributed on the present network. This is an imaginary case in which no improvement will be introduced to the present network for the future. However, this will be used to calculate project benefit by comparing transport cost of this case and a case where a project has been introduced to the present network.
- Road Improvement Case: This case will be carried out to evaluate a road improvement case that includes committed and planned road projects in the city. For this case, the future transport demand will be distributed on a road improvement case network that can be made by adding future road improvement with the present network. In the procedure of transport master plan development, the result of this case will be used to check sufficiency and importance of each road in the improvement plan to come up with a master plan.

(2) Assignment Results

Traffic assignment results will be used to check not only the balance between traffic volume and capacity of each road section but also the efficiency and performance of the whole road network. The former will be discussed in the chapter on road planning while the latter will be described in this section.

The three tables from Table 5.4-4 to Table 5.4-6 summarize the results of traffic assignment and show performance indicators for the network of each case. Note that "urban" in the tables means inside Inner Ring Road (IRR) and "suburban" means outside IRR.

Volume capacity ratio of the urban area indicates 0.874 in 2012, which means transport demand is reaching capacity, while that of the suburban area is 0.437, which means there is a surplus in capacity. However, volume capacity ratio in the "Do Nothing" case becomes 1.778 in the urban area and 0.766 in the suburban area. The urban area's congestion in this case is extremely high so that this huge traffic cannot be actually managed, and then some improvement is indispensable.

With comparing the values of "Do Nothing" case and "road improvement" case, there is sufficient improvement in congestion. However, volume capacity ratio in the urban area still remains over 1.2 and this suggests measures more than road improvement such as an introduction of public transport system are necessary in 2035 even for the road improvement case.

The results of the assignment are visually displayed from Figure 5.4-8 to Figure 5.4-10.

Table 5.4-4 Network Performance Indicators for "Existing Case"

Area	Total Length (km)	Total Capacity Distance (1,000 pcu*km)	Average Capacity (1,000 pcu/km)	Total Travel Distance (1,000 pcu*km)	Volume/ Capacity Ratio	Total Travel Time (1,000 pcu*h)	Average Travel Speed (km/h)
Urban	172.8	3,070.1	17,768.7	2,683.5	0.874	122.5	21.9
Suburban	649.8	14,084.3	21,676.3	6,149.7	0.437	162.6	37.8
Total	***822.5***	***17,154.5***	***20,855.5***	***8,833.3***	***0.515***	***285.1***	***31.0***

Source: PPUTMP Project Team

Table 5.4-5 Network Performance Indicators for "Do Nothing Case"

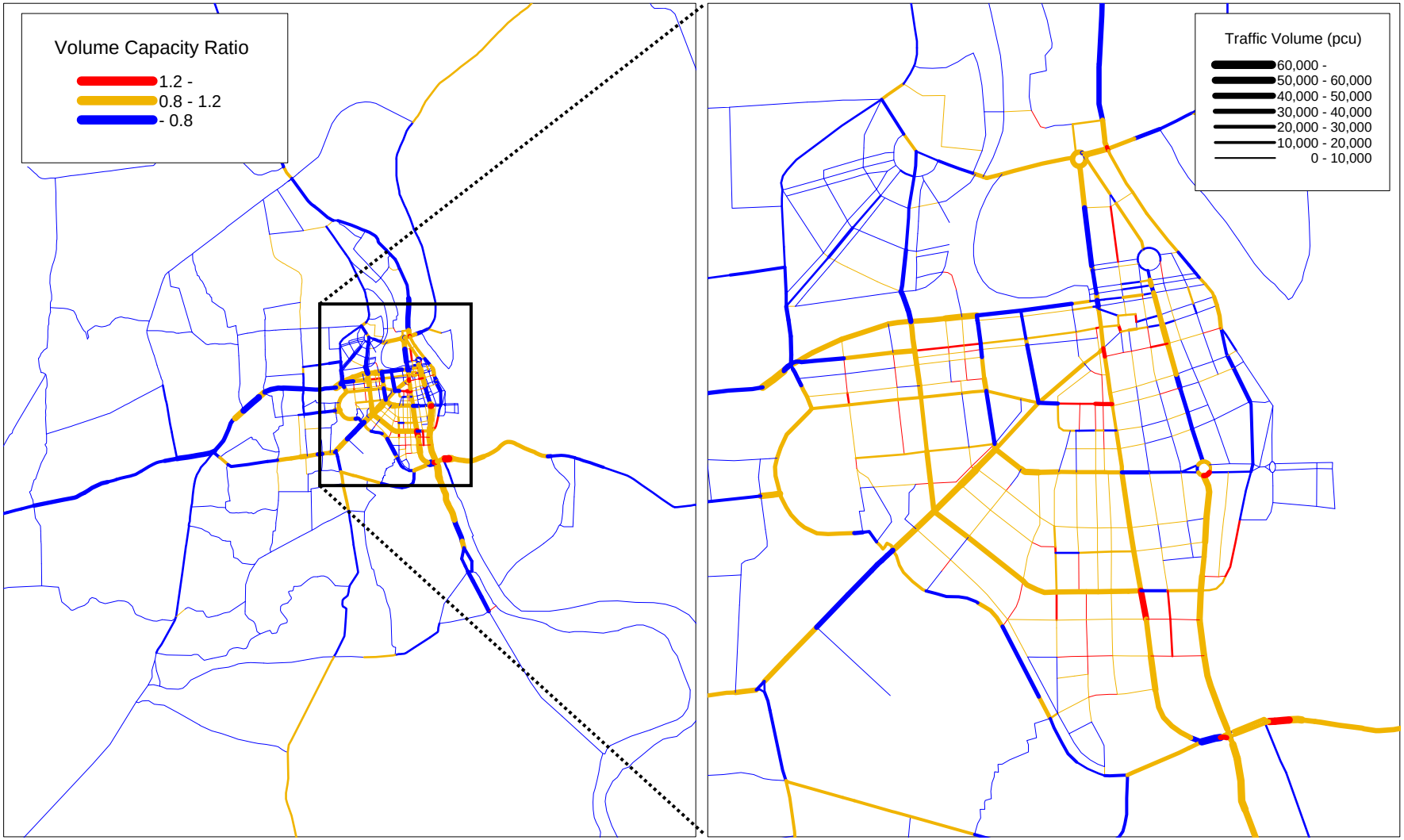
Area	Total Length (km)	Total Capacity Distance (1,000 pcu*km)	Average Capacity (1,000 pcu/km)	Total Travel Distance (1,000 pcu*km)	Volume/ Capacity Ratio	Total Travel Time (1,000 pcu*h)	Average Travel Speed (km/h)
Urban	172.8	3,070.1	17,768.7	5,457.3	1.778	408.9	13.3
Suburban	649.8	14,084.3	21,676.3	10,782.5	0.766	409.7	26.3
Total	***822.5***	***17,154.5***	***20,855.5***	***16,239.8***	***0.947***	***818.6***	***19.8***

Source: PPUTMP Project Team

Table 5.4-6 Network Performance Indicators for "Road Improvement Case"

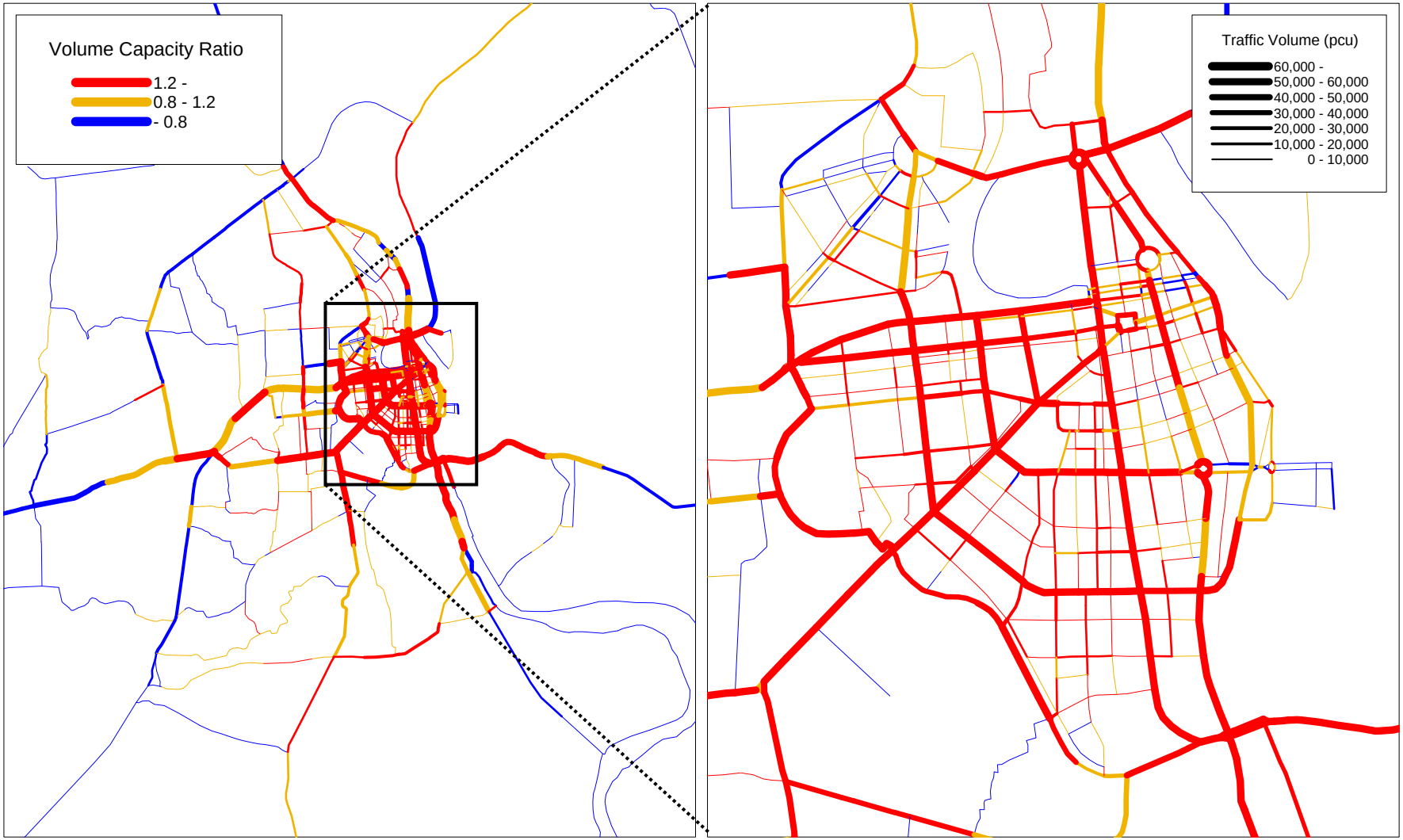
Area	Total Length (km)	Total Capacity Distance (1,000 pcu*km)	Average Capacity (1,000 pcu/km)	Total Travel Distance (1,000 pcu*km)	Volume/ Capacity Ratio	Total Travel Time (1,000 pcu*h)	Average Travel Speed (km/h)
Urban	174.0	3,727.0	21,416.5	4,664.2	1.251	255.4	18.3
Suburban	1,091.1	39,291.0	36,010.0	11,828.2	0.301	301.4	39.2
Total	***1,265.1***	***43,018.1***	***34,002.6***	***16,492.4***	***0.383***	***556.8***	***29.6***

Source: PPUTMP Project Team



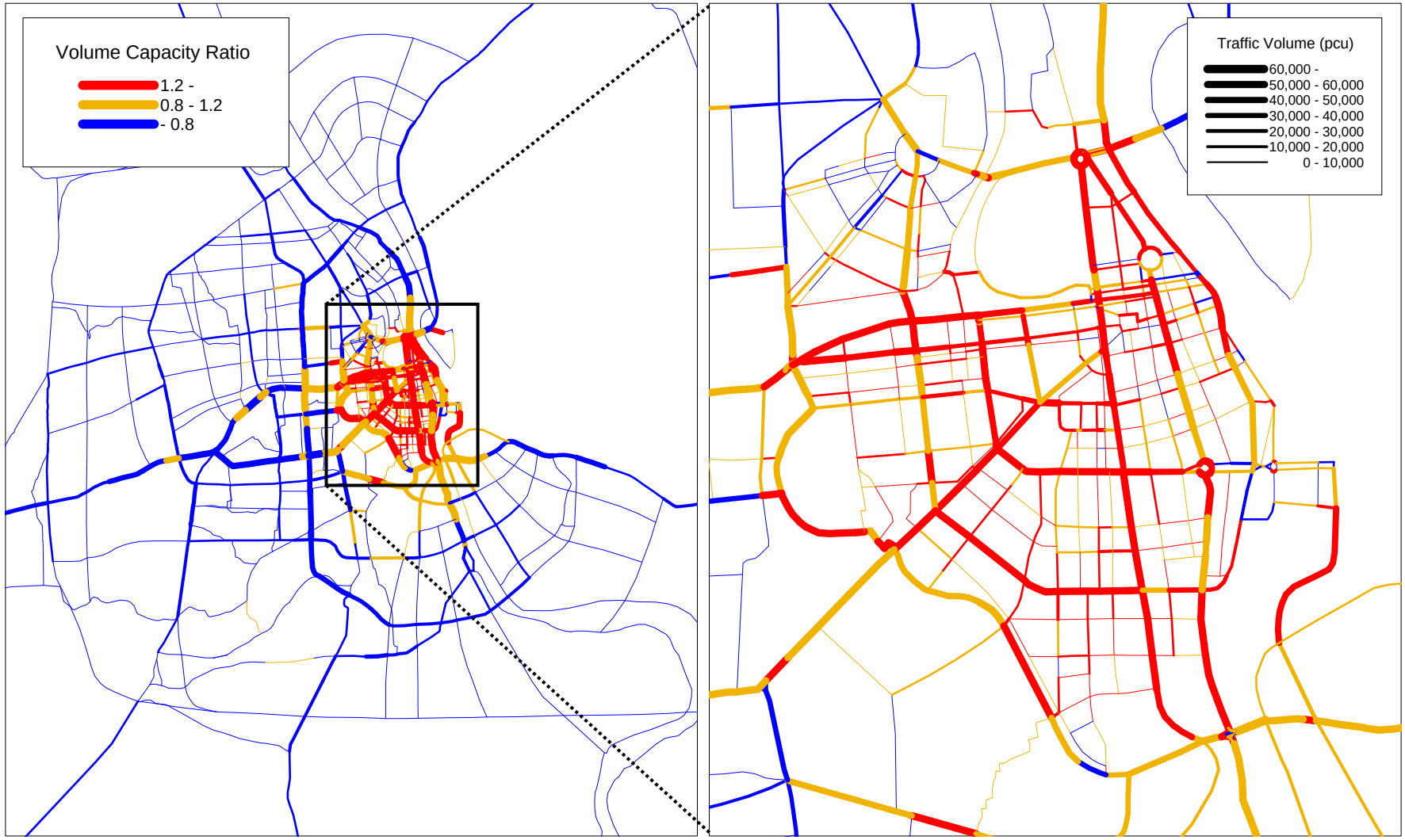
Source: PPUTMP Project Team

Figure 5.4-8 Assignment Result for "Existing Case"



Source: PPUTMP Project Team

Figure 5.4-9 Assignment Result for "Do Nothing Case"



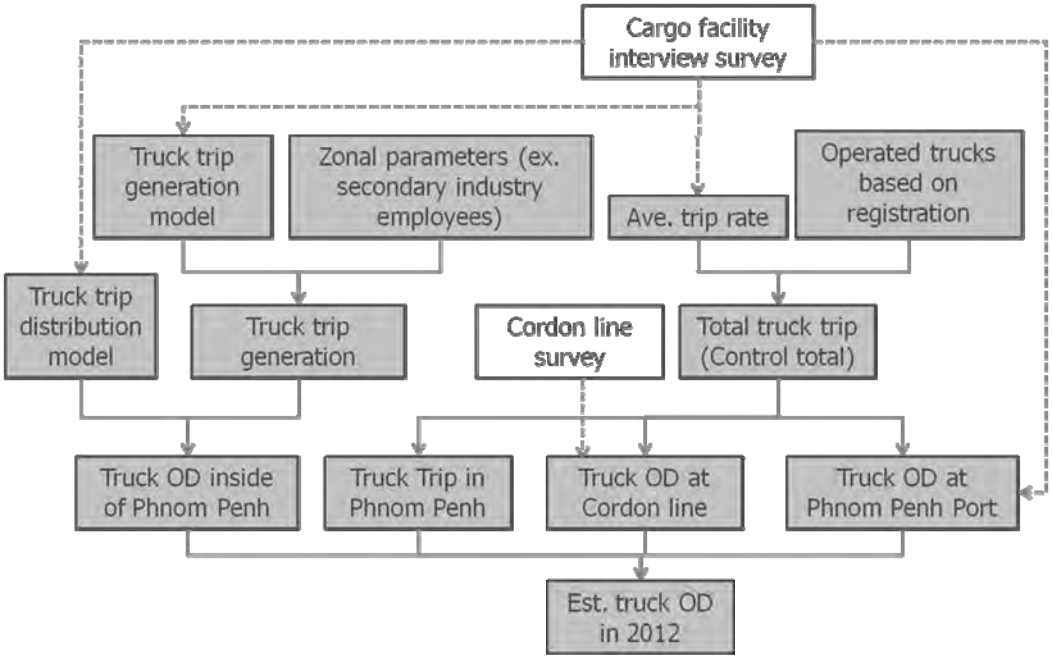
Source: PPUTMP Project Team

Figure 5.4-10 Assignment Result for "Road Improvement Case"

5.5 Freight Traffic Demand Forecast

5.5.1 Estimation of Existing Truck Flow

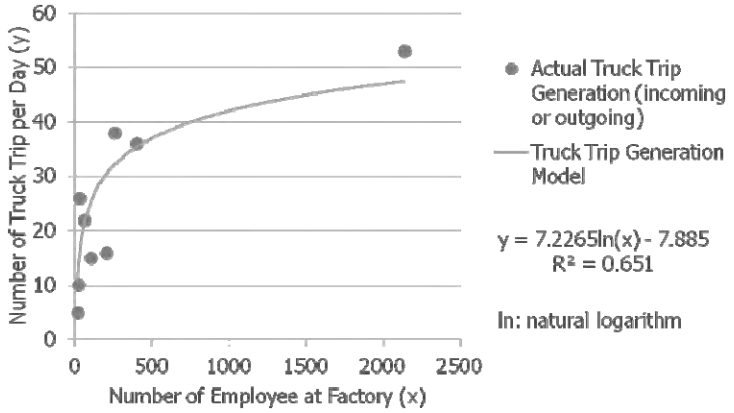
For the estimation of current truck traffic flow in the Project area, truck trip generation by TAZ and truck trip generation are estimated by the models based on results of interview survey at cargo facilities and cordon line survey.



Source: PPUTMP Project Team

Figure 5.5-1 Work Flow of Current Truck Flow Estimation

The interview survey at cargo facilities consists of interviews with operators of facility and with truck drivers at facility. Survey item of operator interview includes type of industry, number of employees and area of company and average daily truck trip generation by type of truck. Truck driver interview survey includes truck trip information such as type of truck, origin and destination, commodity carried and type of package and average number of trips per day. Cargo facility interview was conducted at Phnom Penh Port, 4 cargo facilities such as dry ports and warehouses, and 10 light and heavy factories in PPCC. Truck trip generation by TAZ was estimated by generation model including secondary industry employees as shown in the following figure.



Source: PPUTMP Project Team

Figure 5.5-2 Truck Generation Model (Factory)

Based on number of employees of secondary industry by Economic Census 2011 and estimated truck trip generation model, truck trip generation by TAZ is calculated. Estimated truck trips are divided into three truck types by the following percentages based on the results of the cargo facility interview survey.

Table 5.5-1 Share of Truck Trip Generation

	Light Truck	Truck (Medium)	Heavy Truck	Total
Total Trips	25	125	97	247
Share	10%	51%	39%	100%

Source: PPUTMP Project Team

Estimated truck trips should be adjusted by control total which is estimated by number of registered trucks in the Project area and average trip rate by type of truck by the results of the truck driver interview survey. Number of registered trucks is estimated by the following formula:

$$RT = \alpha + \beta \cdot GDP$$

Where, RT: Number of registered trucks in PPCC,
GDP: Gross Domestic Product (GDP) in constant prices 2000 of Cambodia,
α,β: Parameters.

Table 5.5-2 Parameters of Truck Registration Model

	α	β	Adjusted R2
Light Truck	-5,377.323	3.672	0.959
Truck (Medium)	460.654	1.714	0.910
Heavy Truck & Trailer	-212.38	0.118	0.863

Source: PPUTMP Project Team

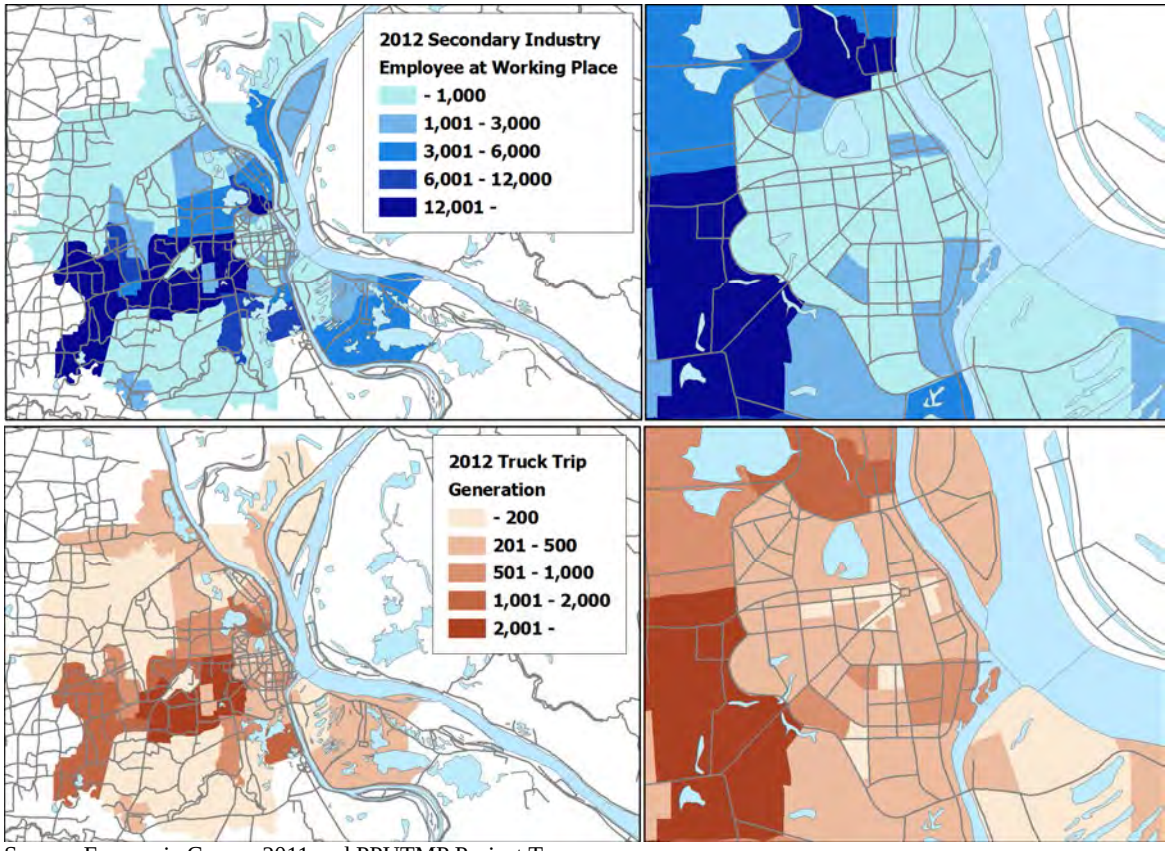
Estimated average truck trips in 2012 shown in below table are the control total of truck generation in the Project area. Average working ratio is a ratio of working trucks per registered trucks, and average trip rate by type of truck is based on the results of the cargo facility interview and truck driver interview surveys.

Table 5.5-3 Truck Working Ratio and Trip Rate

	Est. Registered Truck in 2012 in PPCC	Ave. Working Truck Ratio	Ave. Trip Rate	Est. Truck Trip per day
Light Truck	27,642	100%	2.43	67,300
Truck (Medium)	15,871	95%	2.05	30,800
Heavy Truck & Trailer	852	80%	1.19	800
Total	44,365	-	-	98,900

Source: PPUTMP Project Team

The following figures show distribution of secondary industry employees at working place in the Project area and current truck trip generation estimated by truck trip generation model adjusted by control total.



Source: Economic Census 2011 and PPUTMP Project Team

Figure 5.5-3 Secondary Industry Employees and Estimated Truck Trip Generation in 2012

Truck OD distribution is modeled by following gravity model; however, because of insufficient number of samples and low accuracy of survey, the effectivity of this model is low.

$$T_{ij} = e^{\alpha \cdot TP_i^{\beta} \cdot TA_j^{\gamma} \cdot D_{ij}^{\delta}}$$

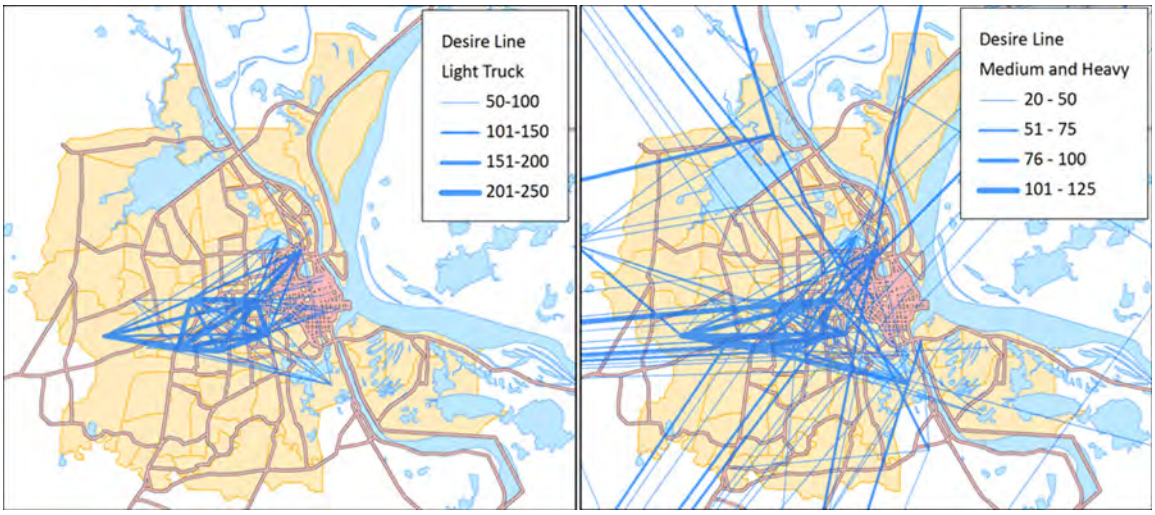
Where, *Tij*: Truck Trip (trip per day),
TPi: Trip Production at Zone i,
TAj: Trip Attraction at Zone j,
Dij: Inter-zonal Impedance (distance in kilometer), and
$\alpha, \beta, \gamma, \delta$: Parameters

Table 5.5-4 Truck Trip Distribution Model Parameters

	α	β	γ	δ	coefficient
Light Truck	1.518	0.056	0.123	-0.198	0.249
Truck (2 axles)	1.200	0.148	0.096	-	0.321
Heavy Truck & Trailer	2.156	0.061	0.038	-	0.108

Source: PPUTMP Project Team

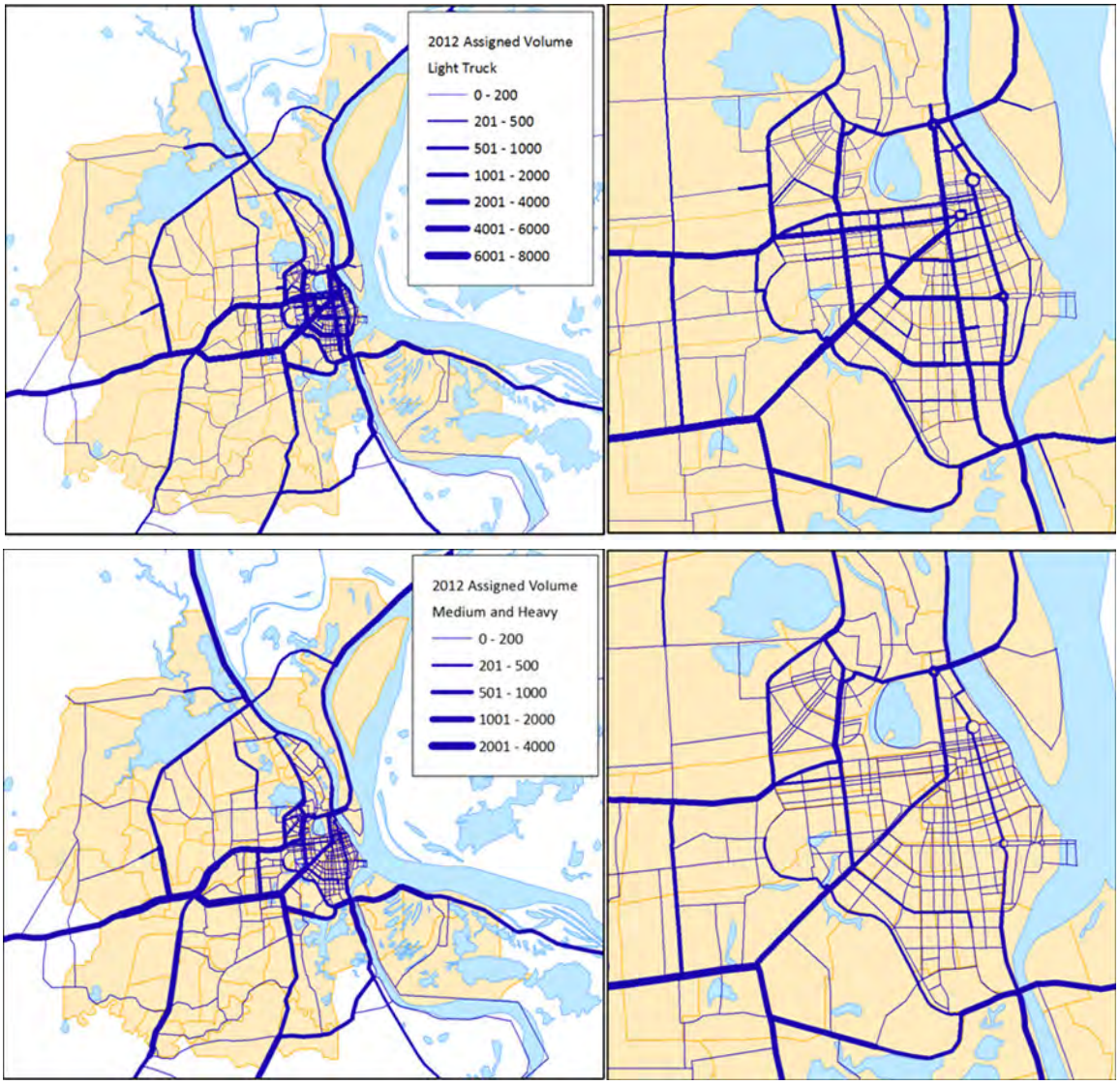
Current truck trip OD is estimated by truck trip generation and distribution model and results of cordon line survey at the boundary of the Project area. The following figure shows the summary of estimated current truck trip distribution.



Source: PPUTMP Project Team

Figure 5.5-4 Estimated Truck Trip Distribution in 2012

Estimated current truck ODs are assigned on existing road network. The results of traffic assignment are shown in the following figures. Assigned truck traffic volume is compared with existing traffic volume surveyed by screen line survey; then adjustment factors calculated by simulated truck traffic volume and observed truck traffic volume by type of truck are applied to existing truck OD to finalize truck OD in 2012.



Source: PPUTMP Project Team

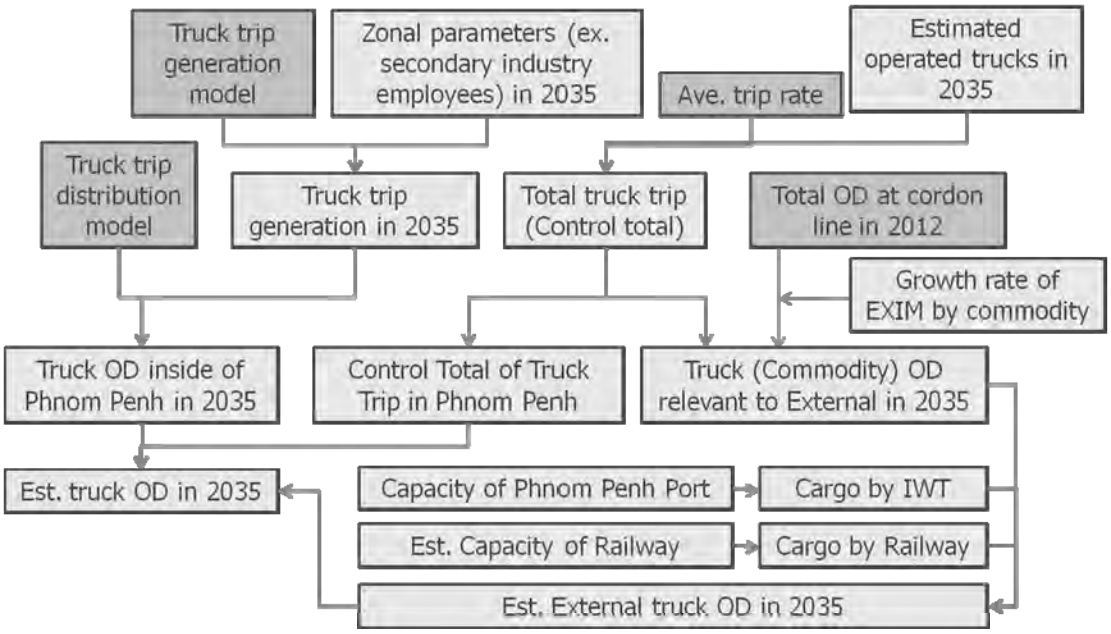
Figure 5.5-5 Assigned Truck Traffic Volume in 2012

5.5.2 Future Truck Flow Forecasting

Future truck trips are basically forecasted by the following work flow. Future truck trip generation is forecasted by truck trip generation model and future zonal attributes, namely, number of secondary industry employees. Total truck trips in the Project area is forecasted by forecasted number of registered trucks estimated by future GDP of Cambodia and average working ratio and average trip rate per day. Trip distribution is calculated by trip distribution model and control total of truck trips in the Project area.

Concerning external truck trips, incoming/outgoing to/from out of the Project area is estimated by existing external truck trips and transported commodities crossing cordon line and forecasted growth rate of export/import commodities of Cambodia. On the other hand, New Phnom Penh Port and Railway's Southern Line have started cargo transport service since end of 2012 and beginning of 2013, respectively; therefore, cargo transport relevant to external of the Project area will be shared by road, railway and inland water transport. The share of inland water transport and railway is defined by

planned or estimated capacity of handling cargo at port and railway service. Estimated cargo demands equivalent to capacity of port and railway are converted to number of truck trips, and origin/destination of those trips also move to port and railway cargo station.



Note: IWT= Inland Water Transport
Source: PPUTMP Project Team

Figure 5.5-6 Work Flow of Future Truck Flow Forecast

(1) Forecasting of Future Internal Truck OD

Internal truck OD in future is forecasted by trip generation and distribution model. Future truck trip generation is forecasted by trip generation model and future zonal parameters. Future truck OD in the Project area is estimated by truck distribution model and estimated trip generation. Forecasted truck OD is adjusted by control total, which is total number of truck trips in 2035 estimated by average trip rate and registered trucks. Control total for internal truck OD excludes external truck trips.

(2) Forecasting of Future External Truck OD

To expand existing cordon line truck OD to future truck OD, growth rate of Export/Import (EXIM) volume is applied as expansion factor by type of commodity. Expansion factor is calculated by i) forecasting existing and future EXIM volume as a control total, ii) estimation of existing and future EXIM volume by type of commodity adjusted by control total, iii) existing and future EXIM volume by direction and iv) calculation of expansion factor by commodity and direction.

Future EXIM volume of Cambodia is forecasted by the following formula:

$\text{Log}(y) = \alpha + \beta * \log(x)$

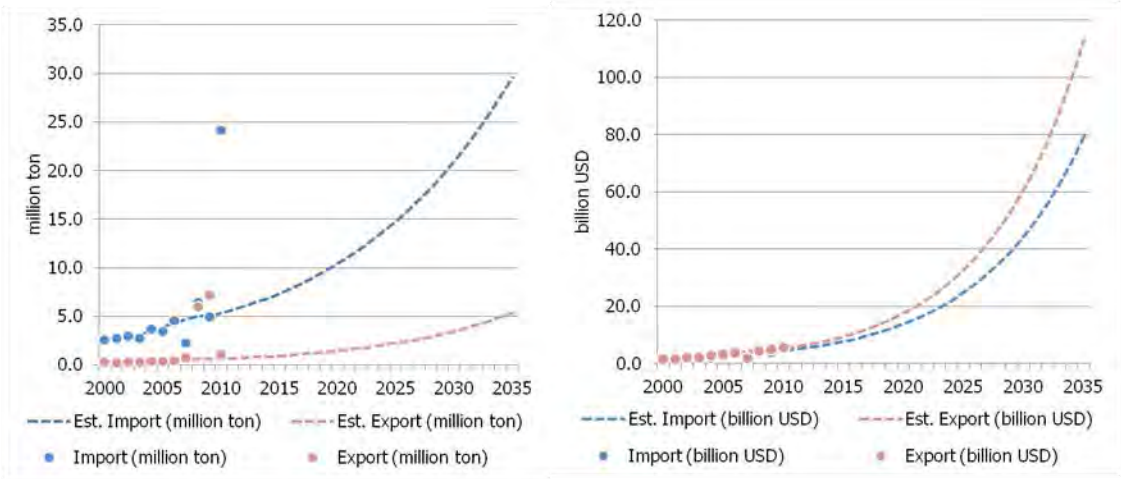
where, y: Import and export volume (1,000 tons, million USD),
x: GDP in Cambodia (million USD in 2000 price), and
α, β: Parameters.

Table 5.5-5 Parameters of EXIM Volume Model

	α	β	Adjusted R2
Import (1,000 ton)	-0.0221	0.961	0.815
Import (million USD)	-2.61	1.607	0.979
Export (1,000 ton)	-1.887	1.202	0.871
Export (million USD)	-2.946	1.712	0.976

Source: PPUTMP Project Team

In 2035, Cambodia's imports and exports are expected at 29.7 million tons, or 79.3 billion USD, and 5.4 million tons or 112.8 billion USD, respectively. The country's total import and export volume in 2035 is expected to be 35 million tons, which is about 54% of handling cargo of Laem Chabang Port in Thailand in 2012.



Source: PPUTMP Project Team

Figure 5.5-7 Forecasted Future EXIM Volume

Future EXIM volume by type of commodity is estimated by regression model built by actual EXIM volume of each commodity and Cambodia's GDP. Estimated EXIM volume of Cambodia is shown in the following table.

Table 5.5-6 Forecasted Future EXIM Volume by Commodity

	Import (1,000 ton)		Import Growth % p.a.	Export (1,000 ton)		Export Growth % p.a.
	2012	2035		2012	2035	
Animal Feed	137	1,087	9.4%	0	3	9.9%
Animal Products	5	26	7.1%	0	0	7.2%
Chemicals	129	670	7.4%	0	0	4.0%
Construction material	341	1,495	6.6%	4	27	8.7%
Fabric	233	385	2.2%	165	879	7.5%
Fertilizer	217	1,444	8.6%	1	11	9.6%
Fruits and Vegetable	27	134	7.1%	22	178	9.5%
Industrial material	67	301	6.8%	3	25	9.0%
Manufactured Goods	313	1,844	8.0%	6	37	8.5%
Minerals	1,780	7,797	6.6%	238	1,953	9.6%
Paper	300	2,191	9.0%	4	22	7.9%
Petroleum	1,702	8,156	7.0%	0	0	N/A
Pharmaceutical	17	41	3.8%	0	2	9.1%
Plant products	56	246	6.6%	68	245	5.7%
Plastic and Plastic products	50	242	7.1%	2	9	8.0%
Rice and Grain Product	48	11	-6.4%	112	994	10.0%
Rubber and rubber products	34	172	7.2%	28	357	11.8%
Seafood	4	24	7.7%	1	3	4.6%
Sugar and Sugar confectionary	35	104	4.8%	3	26	9.9%
Mixing	15	38	4.1%	11	48	6.7%
Machinery	469	3,024	8.4%	55	451	9.6%
Brewery	43	275	8.4%	10	85	9.8%
Total	6,024	29,709	7.2%	733	5,357	9.0%

Source: PPUTMP Project Team

Forecasted future EXIM volume of Cambodia is divided into three directions. The share of these three directions represents the total of trade volume during 2000 - 2010 by trading partner based on the United Nations Commodity Trade Statistics Database. These three directions are defined as follows:

- Thailand and Western: Trade with Thailand and western countries such as Singapore, Malaysia, Indonesia, India, Middle East, Europe and Africa via Sihanoukville Port or NR5 and railway's Northern Line.
- Vietnam and Eastern: Trade with Vietnam, East Asia and North America by NR1 or NR7, inland water transport through existing or new Phnom Penh Port and Cai Mep - Thi Vai International Port in Vietnam.
- North: Trade with Lao PDR through NR7.

The following table shows estimated EXIM volume of Cambodia in 2012 and 2035 by commodity and direction. An expansion factor which is calculated by EXIM volume in 2012 and 2035 is applied to expand existing external truck OD by cordon line survey on the boundary of the Project area to estimate truck and commodity OD in 2035.

Table 5.5-7 Forecasted EXIM Volume and Expansion Factor for Cordon Line

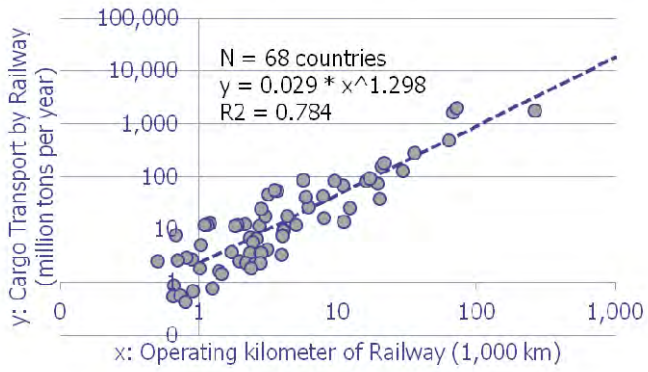
unit: 1,000 tons/year

		Thailand and Western (Sihanoukville)			Vietnam and Eastern (PPCC)			North (Lao PDR)		
		2012	2035	2035 /2012	2012	2035	2035 /2012	2012	2035	2035 /2012
Animal Feed	Export	0	0	8.8	0	2	8.8	0	0	-
	Import	112	893	7.9	24	194	7.9	0	0	-
Animal Products	Export	0	0	0.0	0	0	0.0	0	0	0.0
	Import	4	0	0.0	1	0	0.0	0	0	-
Chemicals	Export	0	0	2.5	0	0	2.5	0	0	2.5
	Import	72	375	5.2	57	295	5.2	0	0	5.2
Construction material	Export	0	2	6.8	4	25	6.8	0	0	6.8
	Import	125	548	4.4	216	947	4.4	0	0	4.4
Fabric	Export	118	631	5.3	47	248	5.3	0	0	5.3
	Import	29	48	1.7	204	337	1.7	0	0	1.7
Fertilizer	Export	1	8	8.3	0	4	8.3	0	0	-
	Import	98	654	6.7	119	790	6.7	0	0	-
Fruits and Vegetable	Export	10	79	8.0	12	99	8.0	0	0	-
	Import	18	88	4.9	9	46	4.9	0	0	-
Industrial material	Export	2	15	7.3	1	10	7.3	0	0	7.3
	Import	28	125	4.5	39	177	4.5	0	0	4.5
Manufactured Goods	Export	3	16	6.5	3	20	6.5	0	1	6.5
	Import	208	1,228	5.9	104	616	5.9	0	1	5.9
Minerals	Export	124	1,015	8.2	112	924	8.2	2	14	8.2
	Import	1,658	7,262	4.4	119	520	4.4	3	15	4.4
Paper	Export	1	4	5.7	3	19	5.7	0	0	5.7
	Import	153	1,116	7.3	147	1,075	7.3	0	0	7.3
Petroleum	Export	-	-	-	-	-	-	-	-	-
	Import	796	3,814	4.8	906	4,342	4.8	0	0	4.8
Pharmaceutical	Export	0	2	7.4	0	0	7.4	0	0	-
	Import	12	29	2.3	5	12	2.3	0	0	2.3
Plant products	Export	10	36	3.6	58	208	3.6	0	0	3.6
	Import	42	185	4.4	14	60	4.4	0	1	4.4
Plastic and Plastic products	Export	1	5	5.9	1	5	5.9	0	0	5.9
	Import	19	91	4.8	31	151	4.8	0	0	4.8
Rice and Grain Product	Export	106	940	8.9	6	54	8.9	0	0	-
	Import	38	0	0.0	10	0	0.0	0	0	-
Rubber and rubber products	Export	5	70	13.0	22	287	13.0	0	0	-
	Import	7	37	5.0	27	135	5.0	0	0	5.0
Seafood	Export	0	0	0.0	1	0	0.0	0	0	0.0
	Import	0	1	5.5	4	22	5.5	0	0	-
Sugar and Sugar confectionary	Export	3	26	8.8	0	0	8.8	0	0	-
	Import	31	0	0.0	4	0	0.0	0	0	-
Mixing	Export	7	31	4.4	4	17	4.4	0	0	4.4
	Import	2	4	2.5	14	34	2.5	0	0	2.5
Machinery	Export	47	385	8.2	8	64	8.2	0	1	8.2
	Import	182	1,174	6.5	287	1,850	6.5	0	1	6.5
Brewery	Export	8	66	8.5	2	20	8.5	0	0	-
	Import	31	200	6.4	12	76	6.4	0	0	6.4

Source: PPUTMP Project Team

In accordance with improvement of other cargo transport modes, estimated external truck and commodity OD in 2035 should be shared by trucks and other modes.

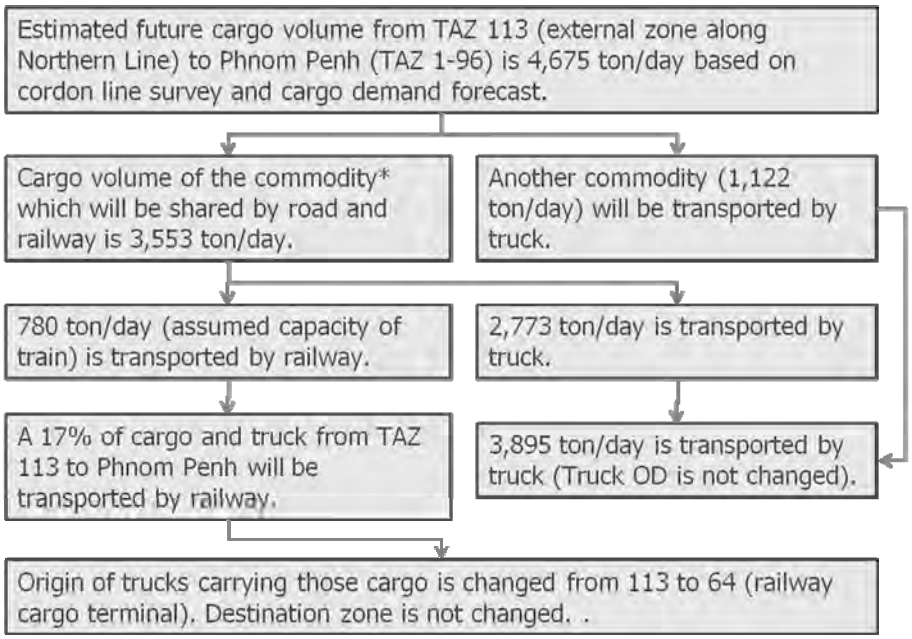
- Cargo through NR5 and Poipet customs at the border of Thailand is currently transported by road because of no alternative mode. By rehabilitation of railway's Northern Line, some part of cargo through Poipet will be shifted to railway.
- Average cargo volume transported by railway is estimated by regression model based on 68 countries as shown in the following figure. The result shows a potential railway cargo transport volume in Cambodia of about 1.07 million tons/year (about 3,000 tons per day).



Source: PPUTMP Project Team

Figure 5.5-8 Regression Model of Actual Cargo Transport and Operating Length

- On the other hand, the capacity of a railway assumed to have a maximum loading of 30 tons per car, 26 cars per train, 4 trains per day (1 train per direction of Northern and Southern Line) and 365 days operation is 1.14 million tons per year and the estimated railway cargo transport potential is 1.07 million tons per year.
- Thus, train capacity is assumed at 780 tons/day/direction (1.14 million tons/year per 4 trains/day).
- Future cargo volume expected to shift from truck to railway's Northern Line is estimated as shown in the figure below.



Note: Construction material, Fabric, Fertilizer, Industrial material, Manufactured Goods, Paper, Petroleum, Rice and Grain Product, Sugar and Sugar confectionary and Mixing are able to be transported by railway.
Source: PPUTMP Project Team

Figure 5.5-9 Work Flow of Modal Shift of Northern Line (Inbound)

- In accordance with service improvement of railway's Southern Line, cargo transport relevant to Sihanoukville Port and Special Economic Zones (SEZs) along the Southern Line will be more shifted from truck to railway. Future cargo volume by road and railway is estimated in the same way as Northern Line's.
- International cargo handled at the existing Phnom Penh Port will be handled at New Phnom Penh Port; therefore, origin or destination of truck trips generated at existing Phnom Penh Port should be changed to New Port in future. As shown in Table 2.6-1, the capacity of New Phnom Penh Port is 500,000 TEUs/year (total of incoming and outgoing cargo). It is equivalent to 4,100,000 tons/year based on the results of the truck driver interview survey (16.0 tons per 40 ft container) and average daily cargo volume is 15,800 tons/day (divided by 260 days/year). Average generated truck trips at New Phnom Penh Port is expected to be 990 vehicles/day (average loading tons of heavy truck is 16 tons/vehicle) and distribution of truck OD from/to New Phnom Penh Port is divided into i) estimated future truck OD moving from existing Phnom Penh Port, and ii) planned SEZ in PPCC and surrounding area. Truck generation at existing and planned SEZs is estimated by regression model based on the cargo facility interview survey.

Table 5.5-8 Forecasted Truck Trip Generation at SEZs

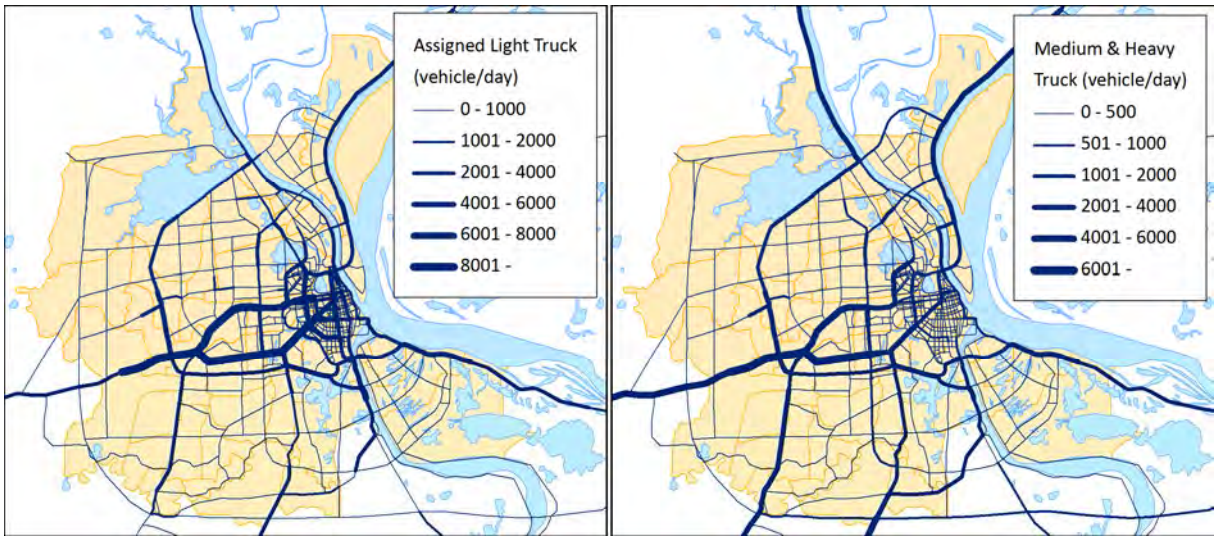
SEZ	Status	Area (ha)	Est. Truck Generation (veh.trip/day)	Traffic Analysis Zone
Phnom Penh SEZ	Operated	350	120	66
Gold Fame Pak Shun	Authorized	80	100	101
Duong Chhiv	Authorized	79	79	109
Phnom Penh New Port	Proposed	250	110	101

Source: PPUTMP Project Team

- Existing Phnom Penh Port is expected to be used for domestic cargo port for such commodities as agricultural products from upper region of the Mekong River to PPCC. Currently such agricultural products are transported by truck, and it will be transported by inland water transport in the future. Estimation of domestic cargo volume at existing Phnom Penh Port involves the following: i) estimation of future cargo volume which is expected to shift from truck to inland water transport such as minerals, plant products, rice and grain product based on forecasted future cargo volume. Estimated domestic cargo volume from upper Mekong River unloaded at existing Phnom Penh Port is about 870 tons per day. On the other hand, actual import cargo volume at existing Phnom Penh Port in 2011 was 410,000 tons/year; thus, capacity of port is estimated at 1,600 tons/day. Estimated domestic cargo shifted from truck to inland water transport is able to be handled by existing port facility; ii) with mode shift of those cargo from truck to inland water transport, trip end of forecasted truck OD is modified.

The results of traffic assignment of modified truck OD in 2035 on future road network is shown in the following figure. This assignment results are based on existing road regulations such as prohibition area of heavy trucks in the city center.

Based on the forecasted truck OD matrices and road network, cargo transport strategy in the Project area is considered and evaluated.



Source: PPUTMP Project Team

Figure 5.5-10 Assigned Truck Traffic Volume in 2035

6 FORMULATION OF 2035 URBAN TRANSPORT MASTER PLAN

6.1 Goal, Mission and Target of the Master Plan

6.1.1 Goal and Mission

The introduction of public transport in Phnom Penh Capital City (PPCC) which was proposed by the Urban Transport Master Plan in 2001 (JICA 2001MP) has not materialized to date. On the other hand, the city has been developed by supporting only a road-oriented transport system.

However, the traffic congestion rate in the City Center is still more than 1.00 (1.25) by traffic demand assignment on only the 2035 road network, as described in Chapter 5, and the new road development in the city center is very limited, especially major trunk roads located in the dense city area. It is obvious that serious traffic congestions exist because of the continuous population influx, and the uncontrolled motorcycle and car increase together with limited road space. To solve these serious traffic conditions fundamentally, it is necessary to change the road-oriented urban transport system and make more effective use of the limited urban road space.

On the other hand, the following problems and issues are also pointed out considering the traffic behavior of Phnom Penh's citizens:

- The choice of modes for Phnom Penh citizens is very limited. Many of them use a motorcycle even for trips of more than 20 km.
- Trip rates between male/female and age groups have a big difference. Females and aged people have lower trip rates. This means that many transportation poor have no chance to make trips, because there is no available mode of transport that is safe, affordable and comfortable.

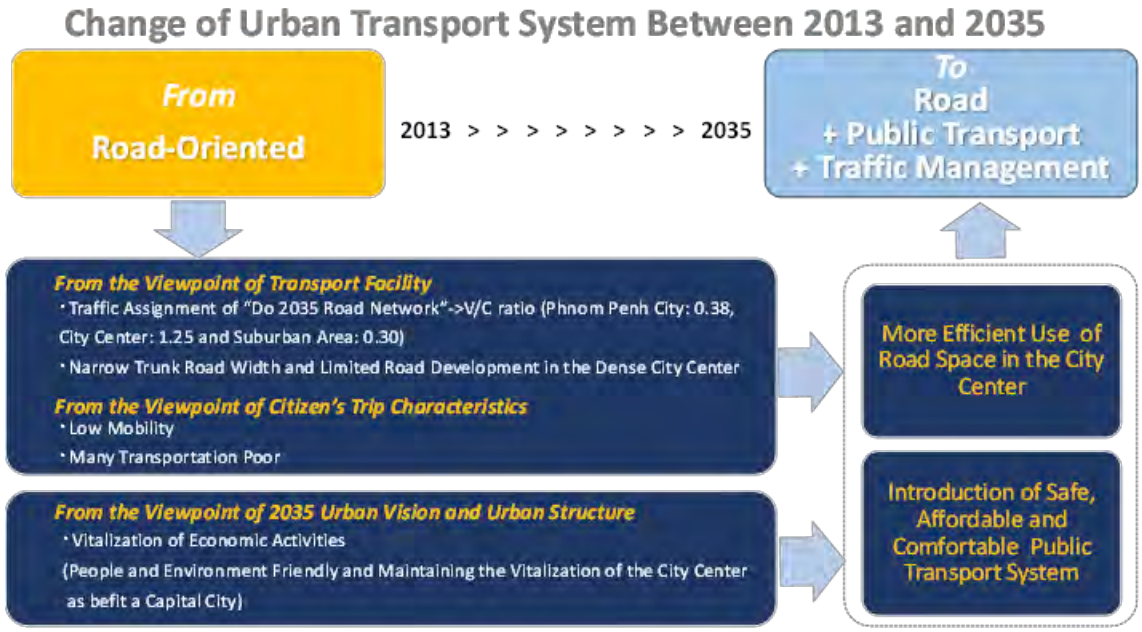
To cope with these, it is necessary to provide an adequate mode of transport considering safety, affordability and comfort of daily trips.

In terms of future vision and urban structure in Phnom Penh City, the following are the key requests in regards to the urban transport:

- To maintain the vitality of Phnom Penh as the Capital City, meaning that many people coming to the city can expect smooth traffic -> to provide large-/medium-sized mode of transport
- To create a people- and environment-friendly city-> to create a more comfortable urban space for the people and increase energy efficiency for use of transport mode

Considering the above, the following have been crafted for Phnom Penh's urban transport master plan in 2035:

- The Goal of the Urban Transport Master Plan: To solve the current transport problems/issues and support the 2035 Urban Vision and Urban Structure, which will maintain the people-/environment-friendly urban conditions and vitalize the urban activities in Phnom Penh City.
- The Mission of the Urban Transport Master Plan, which is two-fold: 1) to shift from a private-oriented urban transport system to a well-balanced system of public and private transport and a combination of road, public transport and traffic management for improving the mobility of citizens and 2) to materialize the urban potential of Phnom Penh City.



Source: PPUTMP Project Team

Figure 6.1-1 Change of Urban Transport System between 2013 and 2035

6.1.2 Target

The following four target indicators are set for the evaluation of the urban transport master plan. It is necessary to achieve the targets to materialize a people and environmentally friendly capital city. And these indicators are one of the most important evaluation factors to assess the master plan alternatives as described in Section 6.6.

Target indicator 1: To develop the urban transport system with more than 30% of total trip makers using public transport in 2035. Verification of target public transport modal share refers to Appendix 5.

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/hour.

Target indicator 4: The urban transport system with 10% reduction of volume of air pollutants from vehicles in the "Do-Nothing" case will be developed for the materialization of a sustainable environmentally friendly city.

6.2 Development of the Master Plan Strategy

Considering the current urban transport problems/issues, future urban structure and traffic demand forecast, the following four strategies are set for the materialization of the mission of the master plan.

Strategy 1: Formulation of people and environmentally friendly urban transport system with high mobility and catering to the needs of citizens
To achieve this, it is necessary to introduce public transport that is clean, safe, punctual, affordable and operated throughout the day, and performs a seamless transfer between modes.

Strategy 2: Formulation of physical framework of the city and creation of smooth connection between major cities in the Mekong Sub-region
The development of road system is to formulate the urban framework and to provide the road network with an appropriate distance to the spread of the urbanized area and to develop smooth flow in the Mekong Sub-region and preserve the urban environment through the formulation of physical framework.

Strategy 3: Maximize use of existing transport spaces including underground and elevated spaces in the city center
To achieve this, the release of sidewalk to pedestrians, the effective use of local roads (people walk + parking + vehicular traffic), the reuse of railway for urban transport and the effective use of water transport (ferry) are to be considered. It is necessary to consider the use of new urban spaces such as underground and elevated space.

Strategy 4: Efficient traffic flow for commodity
The development of commodity flow planning is to support not only the urban vitality but also a comfortable and safe urban life.

Strategy 5: Environmental/social considerations and establishing appropriate urban transport-related organizations are the fundamental concept to develop the master plan
The key of sustainability of the Master Plan is the comprehensive environmental considerations. The keys of materialization and sustainability of the Master Plan are the establishment of an appropriate urban transport-related organization, considering financial mechanisms including private participation and the participation of many stakeholders.

6.3 Master Plan Formulation

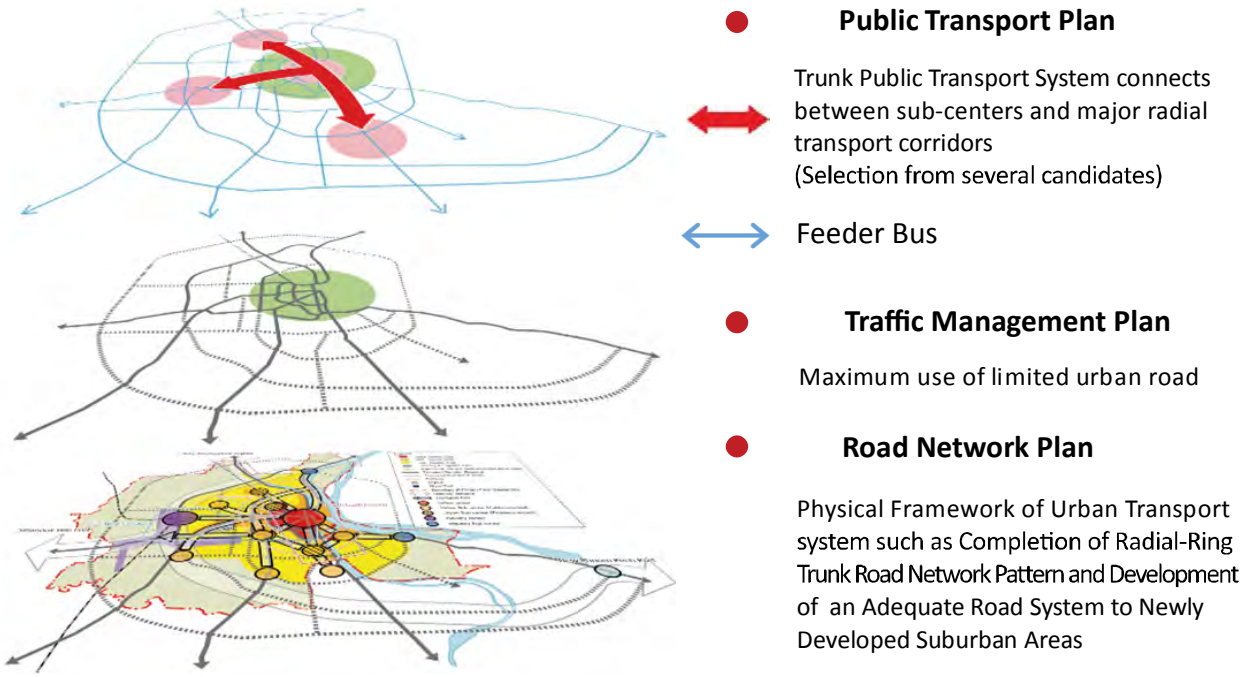
Based on the previous section (6.1: Goal, Mission and Targets and 6.2: Strategy) of this chapter, the urban transport master plan outline is formulated step by step as shown below.

a) Planning concept (relationship between urban transport system and urban structure): Section 6.4,
b) Contents of the urban transport system (master plan's main components): Section 6.5,
c) Proposed urban transport system alternatives: Section 6.6,
d) Evaluation of alternatives: Section 6.7 and the recommended conceptual picture of the master plan: Section 6.8,
e) Master plan components by sector: Section 6.9, and
f) Roadmap to the master plan materialization: Section 6.10.

6.4 Planning Concept

6.4.1 Relationship between Urban Transport System and Urban Structure

The urban transport system, which is the main component of the master plan, is an important basic framework for supporting the future urban structure. This concept of physical structure mainly consists of 4 levels, namely, urban structure level plus 3 main components of the Master Plan (road network level, public transport level and traffic management consisting of supporting measures to maximize the road and public transport but which are difficult to present as an overall physical plan) as shown in Figure 6.4-1.



Source: PPUTMP Project Team

Figure 6.4-1 How to Support the 2035 Urban Structure

6.5 Contents of the Urban Transport System

6.5.1 Road

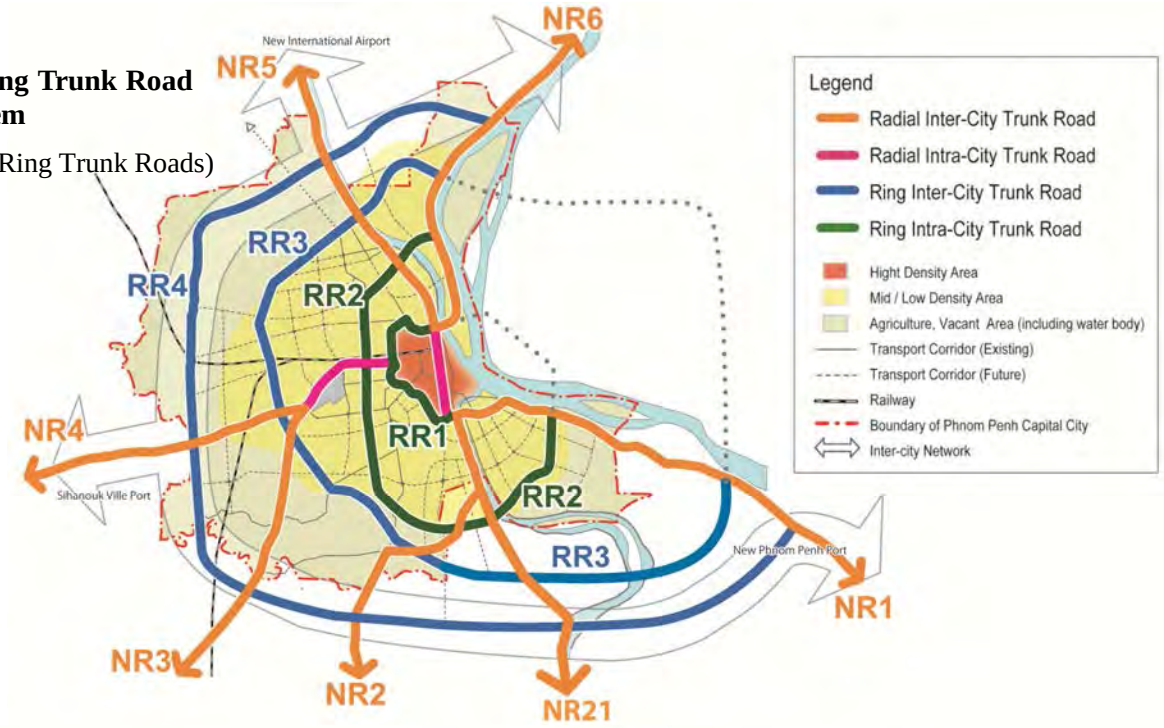
Future road system in PPCC, which is the basic framework of the master plan, forms the city's backbone providing support for the smooth person trips and commodity flow in the Mekong sub-region. Planning policies of the road network system in the master plan are as follows:

a) The road network plan in 2020MP as the future direction of the road network based on the current radial-ring pattern road network system and considering the expansion of the city's boundary.
b) 2035 urban structure and future traffic demand.
c) Development of new ring roads to increase the function of Asian Highway and to preserve the urban environment.
d) Maximize the use of traffic management schemes especially in the dense city center where the development of new roads is difficult.
e) New road development considering the proper road network distance to cope with the future population increase and to properly guide the large-scale development by the private sector.
f) New road development considering enough road space for the introduction of public transport system, the urban environment and urban disaster prevention.

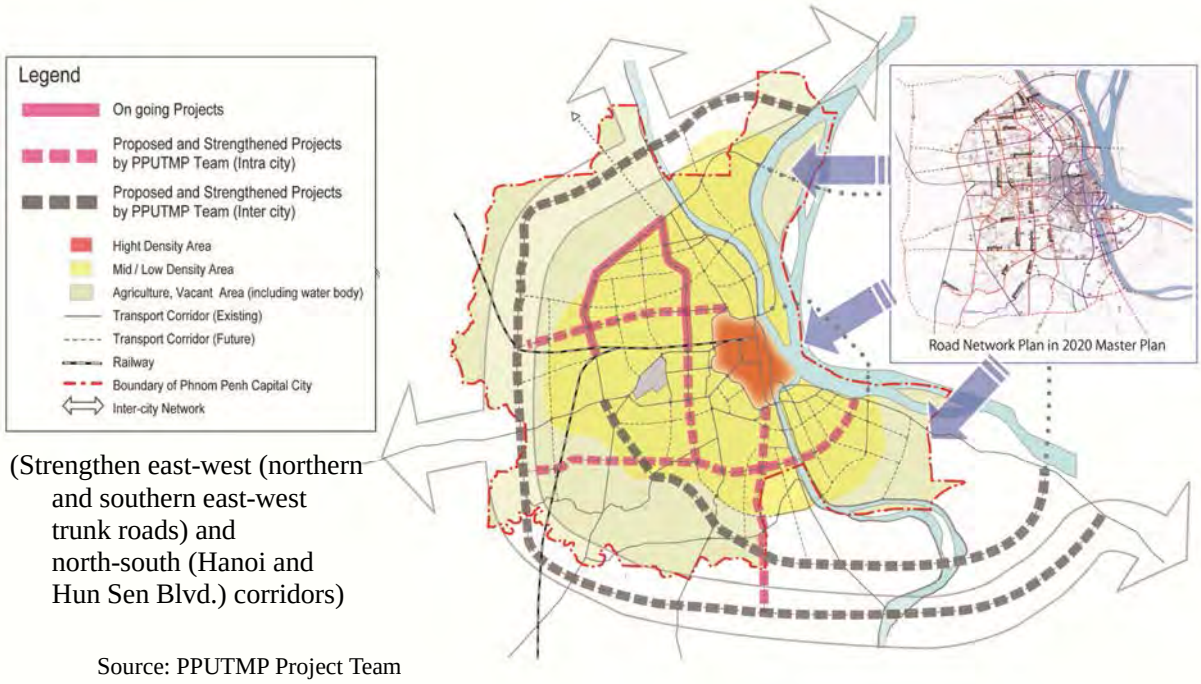
Based on the above, an outline of the 2035 road network and its planning policies are also illustrated in Figure 6.5-1. Details are given in Chapter 8.

Radial and Ring Trunk Road Network System

(6 Radial and 4 Ring Trunk Roads)



(Strengthen east-west (northern and southern east-west trunk roads) and north-south (Hanoi and Hun Sen Blvd.) corridors)



Source: PPUTMP Project Team

Figure 6.5-1 Outline of the 2035 Road Network and its Planning Policies

6.5.2 Public Transport

(1) Why the Need for Public Transport?

Study and analyses performed by the Project point out the following facts that clearly show the need for public transport in PPCC.

a) Limited road space in the city center and slow road development speed in the suburban area
It is impossible to cope with the increased traffic by focusing solely on the road system especially in the dense city center where there is no room to develop new roads.
Without public transport in PPCC, it would be impossible to cope with the increase in traffic.

b) Low mobility and many transportation poor
The mobility of many citizens is extremely low because their trip mode choice is limited to private mode such as cars and motorcycles.
According to the Home Interview Survey (HIS) result, travel distance of the motorcycle drivers stretches over 20 km, which might exceed allowable limits of this kind of transport in terms of safety and comfort.
The HIS result also shows an obvious difference in average number of trips by personal attribute of trip makers. For example, females make fewer trips than males (2.3 trips/day and 2.8 trips/day, respectively), and aged persons make fewer trips than the young. These differences might be mostly explained by natural behavioral differences; however, it is pointed out that there are a considerable number of people who cannot make trips due to the non-availability of public transport, so called transportation poor.
To increase the mobility for all citizens and to reduce the transportation poor

c) Negative rather than good reasons for para-transit use
Needless to say, there is no public transport available in PPCC except for the para-transit system such as motodop, motorumok modern (tuk-tuk), which remains an informal mode in the transport supply though it is actually substantially used as public transport.
According to the public transport user's interview survey, "cheap" and "convenient" are the main reasons for using the motodop rather than "comfort/good accessibility". Some 8% of users even answered that they have no other choice of other transport means but the motodop.
This fact clearly shows that the motodop is selected not for any good reasons but rather because no other option exists for potential public transport users.

d) Comparison of public transport system between major Asian cities
A comparison was made of six cities with almost the same area and population size as PPCC. All sample cities, except for PPCC have a public transport system. In fact, many of them have several alternative systems (refer to Table 6.5-1 and Figure 6.5-2). It can be said that a public transport system especially the bus system is the minimum requirement for dense city centers and this is proved by the graph shown in Figure 6.5-3. The graph is a result of a study conducted in the JICA 2001MP that compared the public transport system in a number of Asian cities considering population size and Gross Domestic Product (GDP) per capita. As can be seen from the graph, it is obvious that the cities with a population of more than one million and a per capita Gross National Product (GNP) of more than US$50.00 operate a public transport system of not only bus but also rail transit.

Table 6.5-1 Indicators of Six Cities

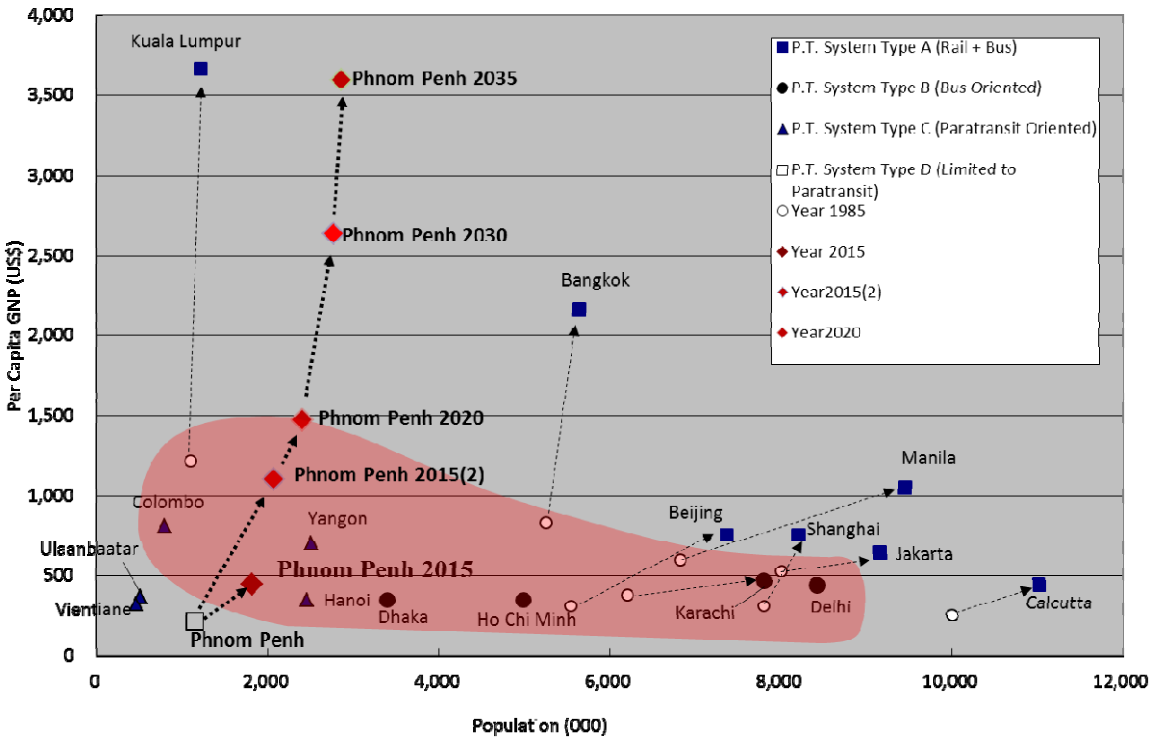
Name of City	Country	Area (km2)	Population (000 persons)	Per Capita GDP (USD)
PPCC	Cambodia	678	1,502	900
Hanoi	Vietnam	918	3,145	1,411
Kuala Lumpur	Malaysia	243	1,627	9,656
Lyon	France	613	1,502	42,337
Hiroshima	Japan	918	1,180	45,983
Curitiba	Brazil	430	1,789	12,594

Note: Data of Phnom Penh is vear 2010 while the rest is year 2007.
Source: PPUTMP Project Team

Phnom Penh	Hanoi	Kuala Lumpur	Lyon	Hiroshima	Curitiba
・N/A, only para-transit Motodop  Motorumok modern (tuk tuk) 	・Bus 	・Bus  ・Monorail  ・LRT  ・Train 	・Bus  ・Trolley bus  ・BRT  ・Tramway  ・Subway  	・Bus  ・Tramway  ・Train 	・Bus  ・Busway 

Source: PPUTMP Project Team

Figure 6.5-2 Public Transport System in Six Cities



Source: JICA 2001 MP Modified by PPUTMP Project Team

Figure 6.5-3 Comparison between Asian Cities

(2) Where to Plan the Public Transport?

1) Candidate routes for transit corridor

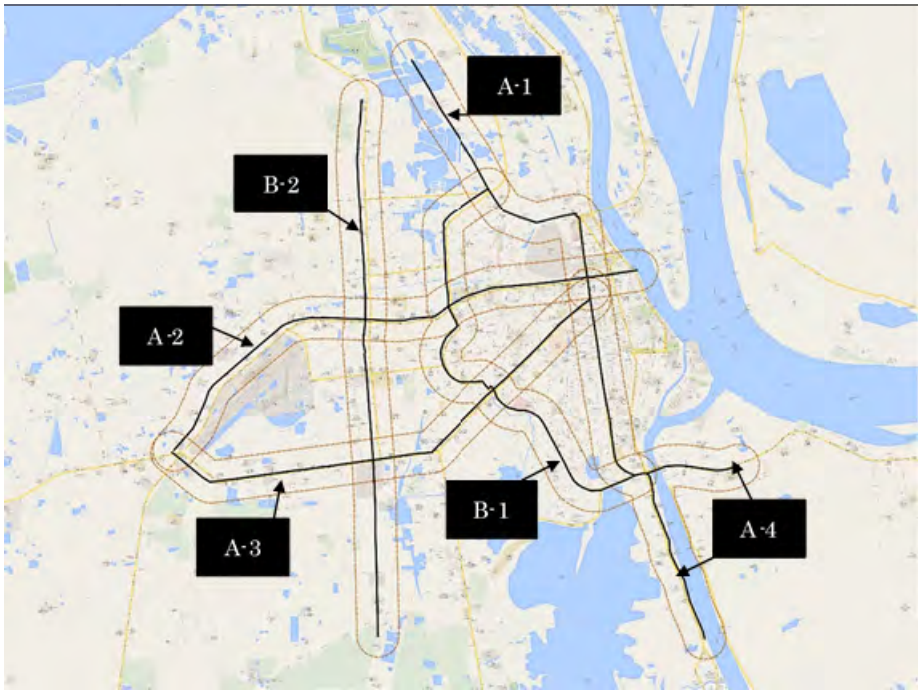
Prior to discussing trunk public transport system, it is necessary to identify the target corridors in which trunk public transport system will be introduced. As its first step, candidate routes for transit corridor are prepared according to the following viewpoint:

- It represents symbolic urban axis by which Phnom Penh has experienced a historical urban development pattern and its urban growth trend.
- In terms of road system, it constitutes a main structure of urban radial roads or ring roads that supports urban structures of Phnom Penh.
- It has a consistent relationship with the future urban structure framework.

As the candidates of transport corridor, 4 routes are selected as described below:

- A-1 route; from central area to north of Tuol kauk along Monivong.
- A-2 route; from central area to Chaom Chao along Russian.
- A-3 route; from central area to Chaom Chao along Monireth and Veng Sreng road.
- A-4 route, from central area to Takmau and MeanChey along Monivong.
- B-1 route; from Tuol Kauk to Preak Ta Nu along Inner ring road 271.
- B-2 route; Ruessei Keo to Dangkao along Hanoi road.

Topographical location of corridors is shown in Figure 6.5-4.



Source: PPUTMP Project Team

Figure 6.5-4 Location of Candidate Routes for Transport Corridor

2) Population of candidate routes

Assuming the specific area covered by candidate routes, which is demarcated by a width of 1 km, the existing and future population densities for candidate routes are estimated, using the population data by TAZ. The result is shown in Table 6.5-2.

Table 6.5-2 Estimated Population Density by Candidate Route

Candidate Route	Length (km)	Population density (P/km^2)		
		2012	2035	Growth Rate
A-1	7.8	14,057.8	18,952.8	1.35
A-2	12.7	13,290.6	16,793.1	1.26
A-3	11.6	19,131.1	22,635.0	1.18
A-4	11.4	16,154.9	20,411.3	1.26
B-1	11.2	17,654.2	21,759.9	1.23
B-2	12.7	5,519.8	9,537.0	1.73

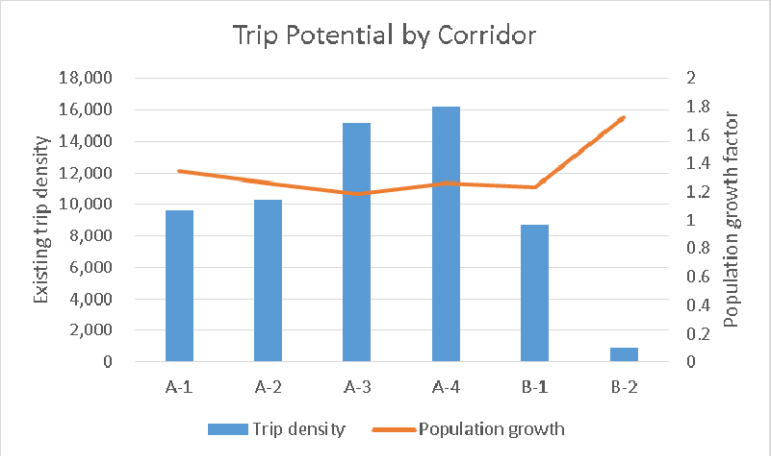
Source: PPUTMP Project Team

- Higher population density is seen in A-3, corridor along Monireth Blvd. and B-1, corridor along IRR 271 while lower population density is seen in B-2, along Hanoi road.
- Regarding the future growth, B-2, A-1 and A-2 which partly include suburban zones show high growth, while A-3 shows low growth rates.
-

3) Trip volume of candidate routes

Figure 6.5-5 shows trip volume density expected by each candidate route, based on the current trip distribution data. The vertical bar represents the density of trips expected along the route, which was calculated in the following way:

- Target area to count of trips is defined by a 1 km wide strip along the route.
- Total trips are estimated by reducing trips between zones in proportion to the share of subdivided area of strip to zones.
- Then trip density was calculated by dividing total trips with the area of target area.
  Lateral line implies supposed growth rate of trips from 2012 to 2035 induced by population growth rate expected along the route.



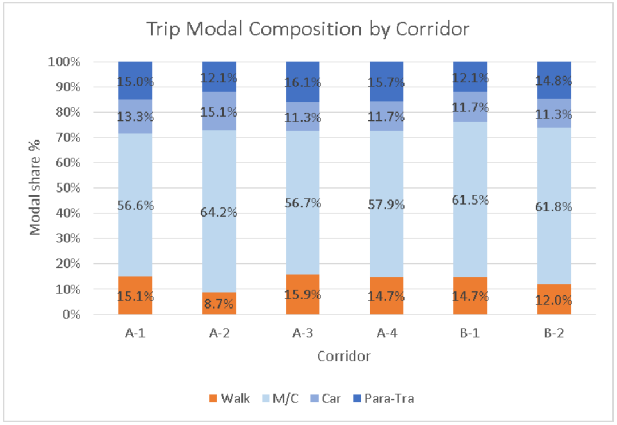
Source: PPUTMP Project Team

Figure 6.5-5 Trip Potential by Corridor

- Large potential trips are expected in A-3 and A-4, followed by A-3 and A-1. B-2 shows relatively small potential because this corridor is located in a suburban area.
  Regarding the growth rate, B-2, A-1 and A-2 have relatively higher rates while A-3 shows a lower rate.

4) Trip characteristics

Figure 6.5-6 shows modal share composition of trips expected along the route.



Source: PPUTMP Project Team

Figure 6.5-6 Modal Share Composition by Corridor

- In terms of motorized transport means other than walk trips, the situation of A-2 is distinct in comparison with other routes because its motorized trip share is more than 90% while that of other routes is 85%, and its car mode share also shows higher share by 4%.
- This means A-2 is a vehicle-oriented corridor and thus is most vulnerable for foreseeable vehicle trips increase in the future.

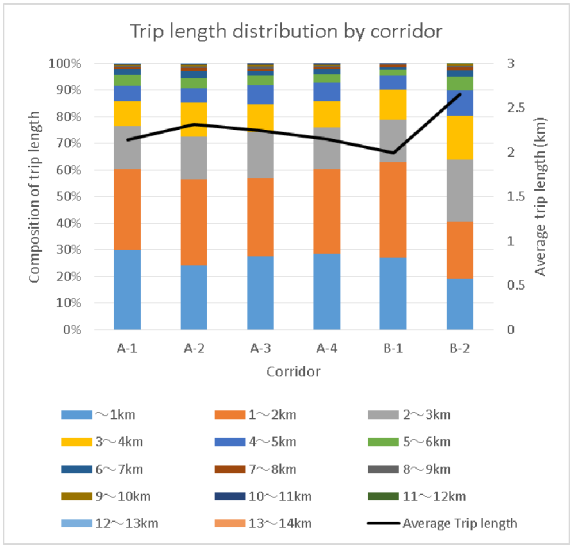
Figure 6.5-7 shows trip length distribution of generated and attracted trips along corridors.

- A check of the average trip length by each route seems to indicate that trip distance for B-2 and A-2 is relatively longer than the others. Especially, the trip length of B-2 is longest. This is because the route is located mostly in a suburban area where trip origin and destination are dispersed due to low density of land use and transport network.
- Meanwhile A-2 also has similar characteristics as B-2 although it is passing along an urbanized area. It seems that the route is commonly used as a major corridor for long range trips due to network connection with N4 and other regional road network.

5) Evaluation of Candidate Routes

Based on the above and additional information, a simple evaluation was conducted, as shown below, in order to select the target corridor for examination of trunk public transport. The following items are adopted as main criteria of evaluation.

a) Accountable in terms of urban axis development in the future;
b) Viability of transit corridor formulation by demand /supply condition;
c) Priority in vehicle traffic deceleration; and
d) Importance in terms of urban policy development.



Source: PPUTMP Project Team

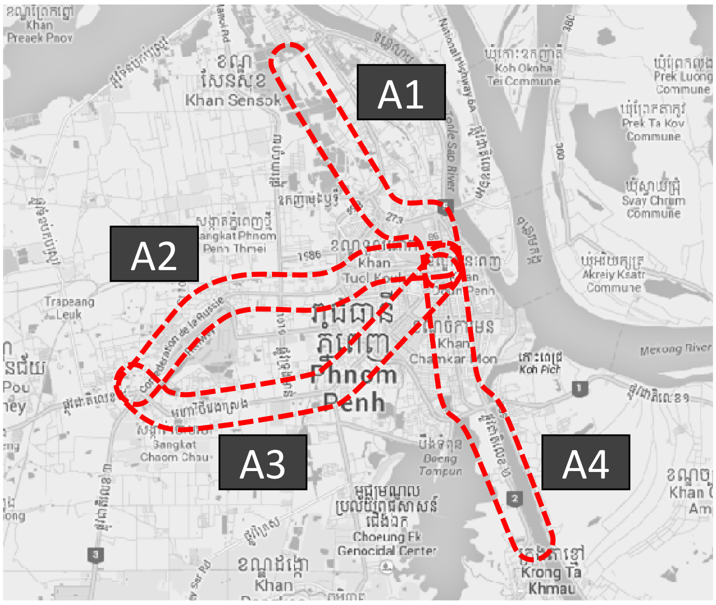
Figure 6.5-7 Trip Length Distribution by Route

Table 6.5-3 Evaluation Result on Candidate Routes of Transit Corridor

Criteria	A-1	A-2	A-3	A-4	B-1	B-2
a) Accountability	++	++	++	++	-	+
b) Viability	+	+	++	++	+	-
c) Priority	++	+++	++	++	-	++
d) Importance	++	++	++	++	-	-
Overall Evaluation	++	++	++	++	-	+

Note: (+) shows relevancy of candidate route for each criteria and (-) shows not available
Source: PPUTMP Project Team

In view of the result above, A-1 through A-4 candidate routes are selected as target transit corridors. Based on the corridor analysis, the trunk public transport corridors and their respective characteristics are shown in Figure 6.5-8.



	Name of Corridor	Corridor Characteristics
A1	North-South Corridor mainly using Monivong (North)	• Enhancing newly north-south urban axis • Decreasing vehicular traffic inflow to city center • Connecting with northern suburban area
A2	West Corridor mainly using Russian /Kampuchea Krom	• Coping with westward urban expansion • Decreasing vehicular traffic inflow to city center • Connecting with western suburban area • Supporting airport access
A3	Southwest Corridor mainly using Monireth /Veng Sreng Road	• Coping with south-westward urban expansion • Connecting with southern suburban area • Supporting urban development along Veng Sreng Road
A4	North-South Corridor mainly using Monivong (South)	• Enhancing north-south urban axis • Decreasing vehicular traffic inflow to city center • Connecting with southern suburban area

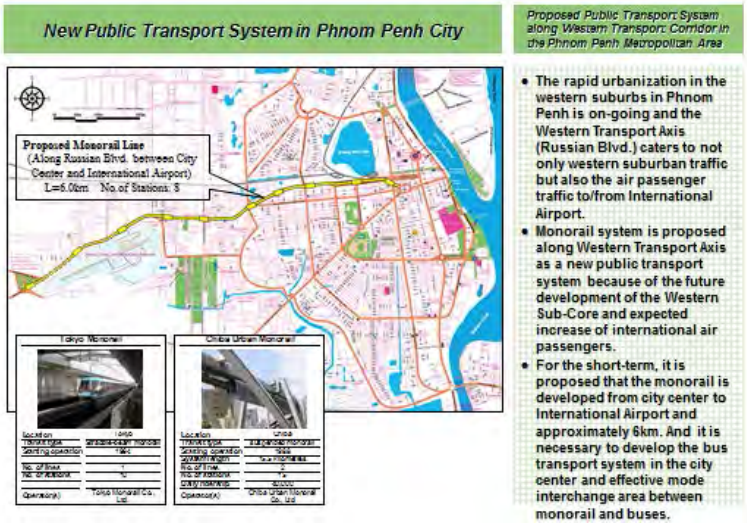
Source: PPUTMP Project Team

Figure 6.5-8 Selected Public Transport Corridors

(3) What Kind of Public Transport System should be Introduced?

Several public transport systems for PPCC have been proposed since early 2000 to cope with the traffic congestions in the city, which is getting more and more obvious. They are as follows:

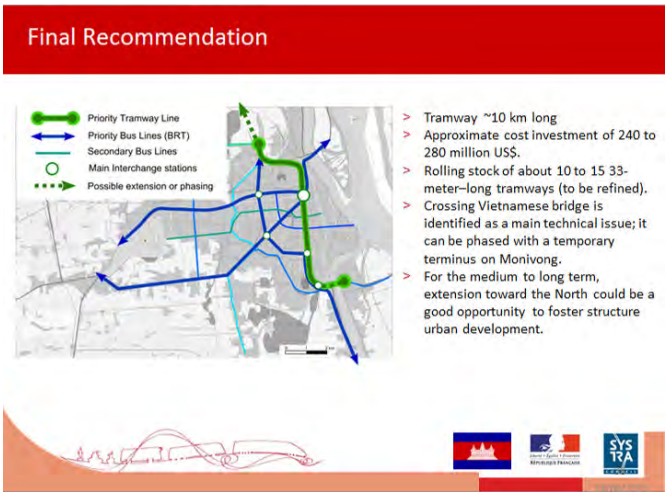
a) Feasibility of the bus operation laid out in the JICA 2001MP. A public experiment was conducted to examine two bus routes, but the service lasted only two months because no agency could be tapped to handle the bus operation and there was lack of financial sources.
b) Feasibility study on Skytrain connecting the city center and the airport. The Skytrain, an elevated rail transit, was proposed by a project funded by the Japanese Government.



Source: Skytrain Study Team

Figure 6.5-9 Feasibility Study of Skytrain

c). Feasibility study on the tramway system networked in the city center was proposed by a project funded by the French government. This is still on-going and the third stage of the project is expected to commence by the end of 2013.



Source: SYSTRA Study Team

Figure 6.5-10 Final Recommendation of Tramway Feasibility

Based on the previous several proposals and such conditions as future vehicular traffic demand and low skyline of the city center, the following public transport candidates are proposed. General characteristics and Japanese examples of these systems are shown in Table 6.5-5 and Figure 6.4-11, respectively.

Public Transport Project No.1 (PT-1) Candidate 1: Bus-Oriented

This road-based system is the most conventional type of public transport that can serve as the trunk public transport and as feeder system of the rail transit. Initial cost is relatively low; therefore, it is easy to introduce especially in small-sized cities such as those with a population of less than a million. But because it is a road-based system, operation punctuality is always dependent on the road conditions. To avoid this, there are several bus priority measures that can be implemented such as the bus priority/exclusive lane and the bus priority signal system.

PT-2 Candidate 2: Bus Rapid Transit (BRT) or Tram
Similar to the first candidate, this is also a road-based public transport system, but unlike the above candidate, it has exclusive space for operation. The system's operational punctuality is secured but it affects other vehicular traffic very much. Therefore, conditions for introducing this system include a wider carriageway (more than 6 lanes) or a clear understanding by the people living along the route that public transport is more important and effective than private mode to their city. It is advisable that this type of public transport be converted into transit mall in the future. Currently, this system is popular worldwide as a tool to trigger a city's vitality especially in the developed countries.

PT-3 Candidate 3: Elevated Rail Transit (LRT or Monorail)
This system can be introduced into cities with a certain level of public transport demand and need for public transport and vehicular traffic to coexist in the busy city center. There are several disadvantages such as 1) its relatively high cost, 2) the carriageway will be reduced due to the columns of the structure and 3) it will block the beautiful scenery in a historical city center such as Phnom Penh's.

PT-4 Candidate 4: Partially Underground Elevated Rail Transit System (LRT)
The three PT-1 candidates mentioned above are based on the previously proposed systems for PPCC. Considering the urban scenery (height of the skyline) in the city center and the citizens' grasp of the importance of introducing a public transport system into PPCC, this candidate (candidate 4) is also proposed.
This system is the most efficient in terms of urban transport such as having the lowest volume-capacity ratio, vehicle-km and vehicle-hour. It is also the most environmentally friendly system among the four PT-1 candidates. In addition, this system can easily coexist with private modes and other public transport systems. On the other hand, the disadvantage of this system is that it is the most costly among the four candidates.

Table 6.5-4 What Kind of Public Transport System should be Introduced?

Type of Public Transport	Right of Way	Remarks
Public Transport (PT) Candidate 1: Bus-Oriented	Surface streets with mixed traffic	Proposed by JICA 2001 MP
PT Candidate 2: BRT or Tram	Longitudinally separated but with at-grade crossing	Proposed by French SYSTRA Team
PT Candidate 3: Elevated Rail Transit	Fully controlled right of way without at-grade crossing	Proposed by METI Project Team in 2009
PT Candidate 4: Partially Underground Elevated Rail Transit		Proposed by PPUTMP project Team

Note: 'Right of Way' is modified from Vukan R. Vuchic's 'Urban Transit: Operations, Planning and Economics'.
'METI' is the Ministry of Economy, Trade and Industry in Japan.

Source: PPUTMP Project Team

Table 6.5-5 General Characteristics of the Various Public Transport Systems

Name of the System	Metro	LRT (Light Rail Transit)	AGT (Automated Guideway Transit)	Monorail	Bus
System Performance (Operating Speed and Distance between Stations)					
Operating Speed	22 - 46 km/h	18 - 40 km/h	21 - 31 km/h	20 - 46 km/h	5 - 15 km/h
Distance between Stations	700 - 2,100 m	400 - 1,000 m	800 - 1,200 m	600 - 2,100 m	300 - 500 m
Service Level (Operating Interval and Passenger Capacity)					
Min. Operating Interval	2 - 7 min.	1 min.	2.5 - 12 min.	3 - 10 min.	-
Passenger Capacity	4,000 - 85,000 passengers/h	6,000 - 20,000 passengers/h	1,000 - 13,000 passengers/h	2,000 - 22,000 passenger/h	2,000 passengers/h
Introduction Space (Introduction Space, Minimum Curvature and Slope)					
Introduction Space	Width: 8,600 * Height: 4,900 mm	Width: 6,000 * Height: 4,500 mm	Width: 6,750 * Height: 3,500 mm	Width: 7,570 * Height: 3,850 mm	-
Minimum Curvature	160 m	Approx. 18 m	25 - 100 m	50 - 120 m	Approx. 9 m
Max. Slope	3.5%	8.0%	2.5 - 6.0%	4.0 - 7.4%	9.0%
Cost (Construction and Maintenance)					
Construction Cost/km (in the case of Japan)	250 - 350 mil. USD	15 - 25 mil. USD	70 - 120 mil. USD	100 - 190 mil. USD	Fleet Cost only

Source: Ministry of Land, Infrastructure, Transport and Tourism (Japan)

Source: PPUTMP Project Team

Figure 6.5-11 Japanese Examples of Candidate Public Transport Systems

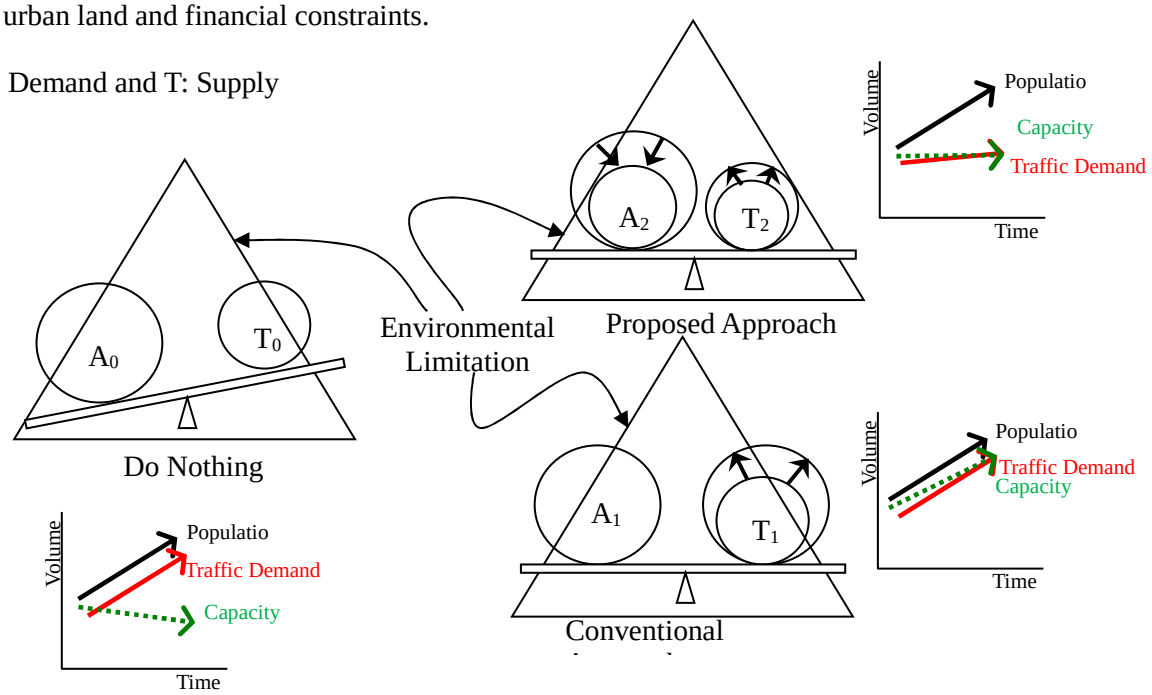
6.5.3 Traffic Management Measures

It is necessary to develop the various supporting measures that will enable the road and public transport to work effectively. Especially, it is important to develop mode interchange areas as convenient transfer points with such facilities as bus stops and rail stations, providing connection between modes, and a well-designed pedestrian environment. The various traffic management measures for the road and public transport system are as follows:

a) Various measures for increasing the attractiveness and comfort of the public transport system
   - Development of various mode interchange areas such as terminals between city buses and intercity buses and a multi-functional transport terminal in the city center
   - Bus priority/exclusive lane and bus priority traffic signal system
   - Bus location system

b) Various traffic management measures such as intersection improvement, traffic signal upgrading and introduction of one-way system
c) Parking policies and measures
d) Pedestrian environment development
e) Restructuring of para-transit such as motodop, motorumok modern (tuk-tuk) and cyclo
f) Reuse of the existing public transport such as railway and water transport
g) Introduction of traffic demand management including mobility management

Traffic demand management (TDM) is one of the many traffic countermeasures used to influence and change the travel needs of people with the eventual aims of reducing traffic congestions, improving traffic safety, saving on fuel consumption and hence reducing vehicle exhaust gases.
Basically, it is an approach that attempts to control the supply side of the transportation economics, by controlling the supply of road and parking spaces in restraining the less efficient private transport modes, while promoting more efficient modes like mass railway transit system in meeting the increases in travel demand brought about by increased economic activities. In this manner, it tries to strike a balance between the increases in demand and supply within the environmental limitations such as urban land and financial constraints.



Source: PPUTMP Project Team

Figure 6.5-12 Concept of Traffic Demand Management

The following figures are Japanese examples of mode interchange area development.

Source: PPUTMP Project Team, Data from OASIS 21

Figure 6.5-13 Bus Terminal in Japan

Hamamatsu Station plaza completed in 1982 including at-grade rounded bus terminal with 77m radius and underground plaza with 55m radius.
Total number of loading/ unloding berths is 20 including 16 rounded bus berths and extra 4 berths.

Source: PPUTMP Project Team

Figure 6.5-14 City Bus Terminal in Front of Hamamatsu Railway Station

Source: PPUTMP Project Team

Figure 6.5-15 Bus Stops with Bus Location System

6.6 Alternative Study

STEP 1: Is it still possible to maintain appropriate urban transport conditions with only road development?

The answer is No, because the target indicators such as congestion rate would not be satisfied even in Case 3.

Case 1: Current Conditions
Case 2: Do-Nothing Case
Case 3: Do Only Road Development Case

The result of the traffic assignment for the above three cases is shown in Table 6.6-1.

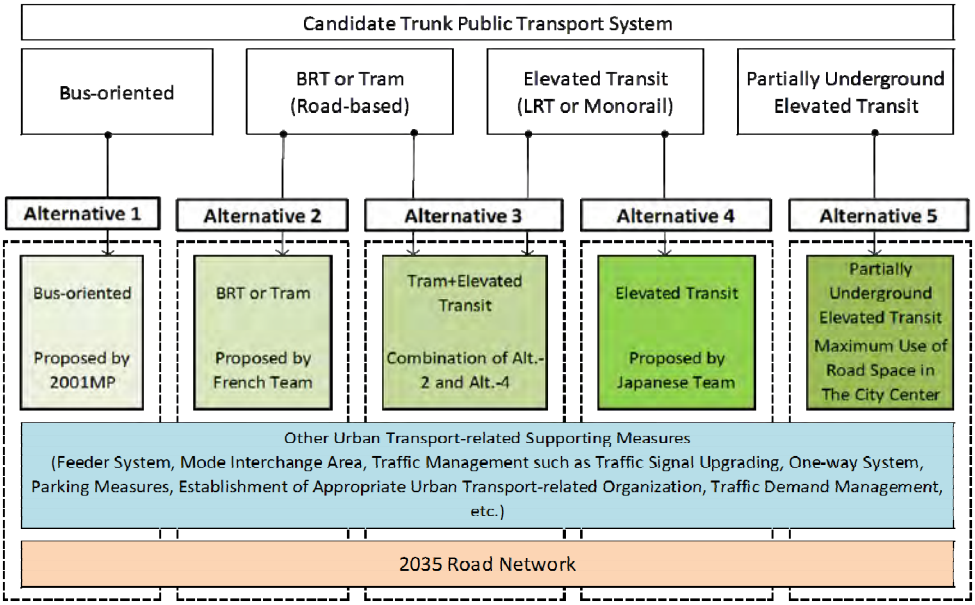
Table 6.6-1 Result of the Traffic Assignment for Case 1, Case 2 and Case 3

Case	Area	Total Length (km)	Total Capacity Distance (1,000 pcu*km)	Average Capacity (1,000 pcu/km)	Total Travel Distance (1,000 pcu*km)	Average Congestion	Total Travel Time (1,000 pcu*h)	Average Travel Speed (km/h)
Current Conditions	Urban	172.8	3,070.10	17,768.70	2,683.50	0.874	122.5	21.9
	Rural	649.8	14,084.30	21,676.30	6,149.70	0.437	162.6	37.8
	Total	822.5	17,154.50	20,855.50	8,833.30	0.515	285.1	31.0
Do-nothing	Urban	172.8	3,070.10	17,768.70	5,457.30	1.778	408.9	13.3
	Rural	649.8	14,084.30	21,676.30	10,782.50	0.766	409.7	26.3
	Total	822.5	17,154.50	20,855.50	16,239.80	0.947	818.6	19.8
Do-road only development	Urban	174	3,727.00	21,416.50	4,664.20	1.251	255.4	18.3
	Rural	1,091.10	39,291.00	36,010.00	11,828.20	0.301	301.4	39.2
	Total	1,265.10	43,018.10	34,002.60	16,492.40	0.383	556.8	29.6

Source: PPUTMP Project Team

STEP 2: What shall we do?
It is not enough to maintain appropriate urban transport conditions with only road development. What is needed is the introduction of a public transport system to achieve the goal of this master plan.
Therefore, the following five alternatives are presented based on the public transport study:

Alternative 1: Bus-oriented + Road Network + Traffic Management Measures
Alternative 2: Tram or BRT (Road-based segregated system) + Road Network + Traffic Management Measures
Alternative 3: Combination of Alt.-2 and Alt.-4 + Road Network + Traffic Management Measures
Alternative 4: Elevated Rail Transit (LRT or Monorail) + Road Network + Traffic Management Measures
Alternative 5: Partially Underground Elevated Rail Transit (LRT) + Road Network + Traffic Management Measures



Source: PPUTMP Project Team

Figure 6.6-1 Components of Proposed Master Plan Alternatives

ALTERNATIVE		ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
COMPONENTS	ROAD	2035 Road Network (6 Radial and Ring Roads System)				
	TRUNK PUBLIC TRANSPORT+BUS	Bus Oriented	Tram	BRT or Tram Elevated Transit	Elevated Transit	Partially Underground Elevated Transit
	TRAFFIC MANAGEMENT	100 Traffic Signal Improvement + One-Way System + Parking Measures + Sidewalk Improvement				
PLAN	—: At-grade —: Elevated ····: Underground					
IMAGE OF PUBLIC TRANSPORT SYSTEM						

Source: PPUTMP Project Team

Figure 6.6-2 Outline of Proposed Master Plan Alternatives

6.7 Evaluation of Alternatives

6.7.1 Evaluation Criteria

The criteria adopted for evaluating the urban transport master plan alternatives are categorized into five aspects, namely, urban transport, urban planning, environmental, economic and stakeholder participation aspects. The category items cover different views on 1) urban transport system alternatives, 2) Strategic Environmental Assessment (SEA), and 3) stakeholder participation.
However, the stakeholder's viewpoint is yet to be reflected in this stage, because the schedule of the stakeholder workshop was pushed back from beginning of June to August 6, 2013.

Table 6.7-1 Evaluation Criteria for Master Plan Alternatives

Evaluation Factor \ Alternative		Scoring Criteria
Urban Transport Aspects	**Traffic Congestion Rate and Travel Speed in the City Center**	Higher speed and congestion rate less than 1.00 is given check.
	Decrease of Vehicle-km and Vehicle-hour	Smaller vehicle-km and vehicle-hours is given check.
	Degree of Mobility	Bigger number of modes is given check.
	Consideration for Transportation Poor	Elderly and handicapped friendly public transport system is given check.
Urban Planning Aspects	**Harmony with Urban Scenery**	Fitting the urban scenery system is given check.
	Contribution to the Urban Vitality	Vitality contributed system is given check.
	Impact to the Tourism	More impression to the tourists is given check.
Environ-mental Aspects	**Decrease of Air Pollutants and Greenhouse Gas Emission**	Lower emission is given check.
	Decrease of Traffic Accidents	Lower possibility of traffic accidents is given check.
	Natural/Social Environmental Consideration	Smaller impact of residents living along the corridor is given check.
Economic Aspects	**Investment Cost**	Lower investment cost is given check.
	Cost-Benefit Ratio	Higher cost-benefit ratio is given check.
Stakeholder Participation Aspects		Conclusion of the stakeholder workshop

Source: PPUTMP Project Team

6.7.2 Evaluation by Four Aspects

(1) Urban Transport Aspects

a) Traffic Congestion Rate and Travel Speed in the city center and b) Decrease of Vehicle-km and Vehicle-hour

i) Methodology

With the demand forecasting approach developed in the previous chapter, this section proceeds

with the evaluation of network alternatives.
The introduction of public transport, which is sometimes called mass-transit, is a trade-off between demand and capacity, namely, the road load decreases because public transport can serve more passengers than private vehicles, but road capacity also reduces because a part of the road space is used to build the infrastructure for the public transport. Therefore, the matters of which route, how long and what type of public transport should be examined and evaluated in the light of the above mentioned viewpoint.
The examination will be carried out by distributing future traffic demand (an OD table) in 2035 on the alternative networks and then evaluating network performance indicators such as volume-capacity ratio and average travel speed. The OD table developed in Chapter 5 is a matrix that shows travel volumes between zones by four modes: walking, motorbike, passenger car, and para-transit, in the case that the present characteristics of vehicle ownership will be expanded according to economic growth and no public transport system is introduced (refer to the base modal shares in the following table). In order to develop the OD table for the examination, it is assumed that modal shift from private vehicle to public transportation happens and the total share of public transport is calculated at 30%.

Here, the following five alternative networks are developed and examined according to the level of service of public transport introduced. Figure 6.7-1 provides a visual representation of the network descriptions.

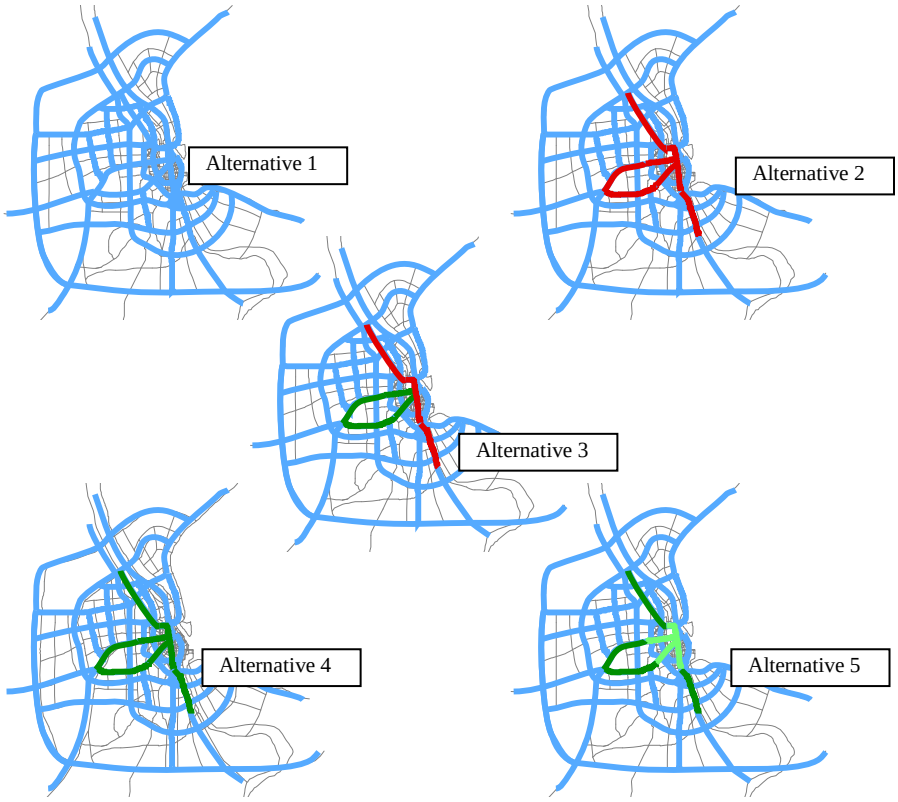
Alternative 1: Bus only case
Ordinary bus system as a public transport means is introduced on the whole network. However, bus routes are not considered in the examination so that buses can be driven on any road section in the network.

Alternative 2: Tram/BRT on surface case
Tram or BRT on surface is introduced on some road sections (red lines in the figure). The capacity of the road sections where public transport is introduced reduces to 2 lanes.

Alternative 3: Elevated LRT + Tram/BRT on surface case
This alternative is a combination plan of Alternative 2 and Alternative 4. As shown in the figure, the capacity of the road sections represented by red lines reduces to 2 lanes and that by green lines reduces to 1 lane.

Alternative 4: Elevated LRT/Monorail case
This alternative introduces an elevated LRT or monorail on the road sections highlighted by green lines in the figure. Those capacities for private vehicles are reduced by 1 lane.

Alternative 5: Elevated LRT/Monorail (partially underground) case
This alternative is an improved plan from Alternative 4. The road sections highlighted by light green lines are constructed underground so that the development does not affect the capacity of private vehicles in these sections.



Source: PPUTMP Project Team

Figure 6.7-1 Establishment of Alternative Networks

ii) Result of Evaluation

The indicators as a result of the examination can be summarized as shown in Table 6.7-2.

Table 6.7-2 Establishment of Alternative Networks

Items	Traffic Assignment Results								Evaluation Factors and Scoring of Urban Transport Aspects	
	Area	Total Length (km)	Total Capacity Distance (1,000 pcu*km)	Average Capacity (1,000 pcu/km)	Total Travel Distance (1,000 pcu*km)	Average Congestion	Total Travel Time (1,000 pcu*h)	Average Travel Speed (km/h)	(1) Traffic Congestion Rate and Travel Speed in the City Center	(2) Vehicle-kilometer and Vehicle-hour in the City
Alt-1	Urban	174.0	3,727.0	21,416.5	4,254.0	1.141	217.5	19.6		
	Rural	1,091.1	39,291.0	36,010.0	10,952.1	0.279	270.5	40.5		
	Total	1,265.1	43,519.7	34,399.1	15,206.0	0.349	488.0	31.2		
Alt-2	Urban	174.0	3,346.9	19,231.8	3,433.6	1.026	166.3	20.6		
	Rural	1,091.1	38,609.1	35,385.0	9,917.1	0.257	235.1	42.2		
	Total	1,265.1	41,955.9	33,163.0	13,350.7	0.318	401.4	33.3		
Alt-3	Urban	174.0	3,412.8	19,610.6	3,428.6	1.005	162.8	21.1		
	Rural	1,091.1	38,833.1	35,590.3	9,857.9	0.254	232.3	42.4		
	Total	1,265.1	42,245.9	33,392.2	13,286.5	0.315	395.1	33.6		
Alt-4	Urban	174.0	3,546.3	20,377.6	3,437.3	0.969	157.8	21.8		
	Rural	1,091.1	38,954.6	35,701.7	9,740.3	0.250	227.8	42.8		
	Total	1,265.1	42,500.9	33,593.8	13,177.6	0.310	385.6	34.2		
Alt-5	Urban	174.0	3,683.7	21,167.3	3,472.4	0.943	155.0	22.4		
	Rural	1,091.1	38,954.6	35,701.7	9,642.4	0.248	224.1	43.0		
	Total	1,265.1	42,638.3	33,702.4	13,114.8	0.308	379.1	34.6		

Note: Better -> Worse

Source: PPUTMP Project Team

c) Degree of Mobility

Degree of mobility is presented as the number of public transport modes available to the citizens and the alternatives having exclusive space for operation which can secure the punctuality of the public transport operation.

d) Consideration for Transportation Poor

The evaluation point considers how friendly the transport system is to the transportation poor such as handicapped and aged people. An example would be if the public transport in the alternative has low floor level to make it easy to board/alight and to transfer.

(2) Urban Planning Aspects

a) Harmony with Urban Scenery

The city's urban scenery shows a relatively low skyline and this is historically important; therefore, the alternative that can preserve this urban scenery, especially considering the impact along Monivong, which is the most popular boulevard in PPCC, gets the highest score.

b) Contribution to the Urban Vitality

This item considers an alternative that has public transport which can be a trigger of the city's vitality. So, the alternative with a number of new public transport modes gets the highest score among the alternatives.

c) Impact to the Tourism

The alternative must possess the charm to attract tourists. In this case, a good-designed tramway which is very popular in Western countries and Japan has the highest score, followed by rail transit.

(3) Urban Environmental Aspects

Environmental scoping was carried out for the urban transport master plan. Main components of the master plan are a) public transport, b) road and c) supporting measures such as traffic management. All of the alternatives have the same conditions for road and supporting measures; therefore, these two components are not evaluated in this urban transport master plan. However, it is necessary to assess the natural/social environmental aspects, because road development is also proposed in this master plan. The supporting measures are mainly traffic management which is composed of soft components such as traffic demand management and even hard components developed within the right-of-way of the roads. Therefore, the impacts on the natural/social environmental aspects are expected to be minor.

The checklist is corresponding to the "Guidelines for Environmental and Social Considerations 2010" by JICA. Some negative impacts are expected for construction and operation period of introducing public transportation and construction of new roads. Generally, the 5 urban transport alternatives are assumed to cause the same impacts even with the differences in scale. In order to compare each alternative, 3 large categories were distinguished, namely, "air pollutants and Greenhouse Gas (GHG) emission", "accidents" and "natural and social environmental consideration" based upon the result of scoping.

Firstly, air pollutants and GHG emission were evaluated quantitatively based upon the estimation of motor vehicle emissions. These numerical predictions were calculated based on future traffic demand by mode. Secondly, accidents were evaluated qualitatively based upon the consideration of possibility by each structure of public transport. Finally, natural and social environmental considerations examined expected noise and vibration, involuntary resettlement and other adverse impacts. These factors were also evaluated qualitatively.

Table 6.7-3 Expected Environmental Impacts Caused by Developing the Urban Transport System (Public Transportation + Road + Traffic Management, etc.)

Item	Construction Period			Operation Period		
	PT	Road	TM	PT	Road	TM
Air Pollution	**Y**	**Y**	N	**Y**	**Y**	N
Water Pollution	**Y**	**Y**	N	N	N	N
Soil Pollution	**Y**	**Y**	N	N	N	N
Waste	**Y**	**Y**	N	N	N	N
Noise and Vibration	**Y**	**Y**	**Y**	**Y**	**Y**	N
Ground Subsidence	N	N	N	N	N	N
Offensive Odours	N	N	N	N	N	N
Geographical Feature	N	N	N	N	N	N
Bottom Sediment	N	N	N	N	N	N
Biota and Eco-System	N	N	N	N	N	N
Water Usage	N	N	N	N	N	N
Accidents	**Y**	**Y**	**Y**	**Y**	**Y**	N
Global Warming	N	N	N	**Y**	**Y**	N
Involuntary Resettlement	**Y**	**Y**	N	N	N	N
Local Economy (Employment and Living Livelihood)	**Y**	**Y**	N	N	N	N
Land Use and Utilization of Local resources	N	**Y**	N	N	**Y**	N
Social Institution (Social Infrastructure and Local Decision-making Institutions)	N	N	N	N	N	N
Existing Social Infrastructures and Services	**Y**	**Y**	N	N	N	N
Poor, Indigenous of Ethnic People	N	N	N	N	N	N
Misdistribution of Benefit and Damage	N	N	N	N	N	N
Local Conflict of Interests	N	N	N	N	N	N
Limitation of accessibility to information, meetings, etc. on a specific person or group	N	N	N	N	N	N
Gender	N	N	N	N	N	N
Children's Right	N	N	N	N	N	N
Cultural Heritage	N	N	N	N	N	N
Infectious Diseases (HIV/AIDS)	**Y**	**Y**	N	N	N	N

Note: Y=YES, N=NO
PT=Public Transport, TM=Traffic Management
HIV/AIDS=Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
Source: The "Guidelines for Environmental and Social Considerations 2010" by JICA for the checklist items.

a) Decrease of Air Pollutants and GHG Emission

Air pollution substances including Total Hydrocarbon Compound (THC), Carbon Monoxide (CO) and Particulate Matter (PM), and GHG including CO2 and Nitrogen Oxide (NOx) are estimated based on each emission factor and future traffic volume by link. The emission factors employed were those used in Thailand delivered from the laboratory result[1] with using a chassis dynamometer. The similarity of vehicles between Cambodia and Thailand such as motorumok

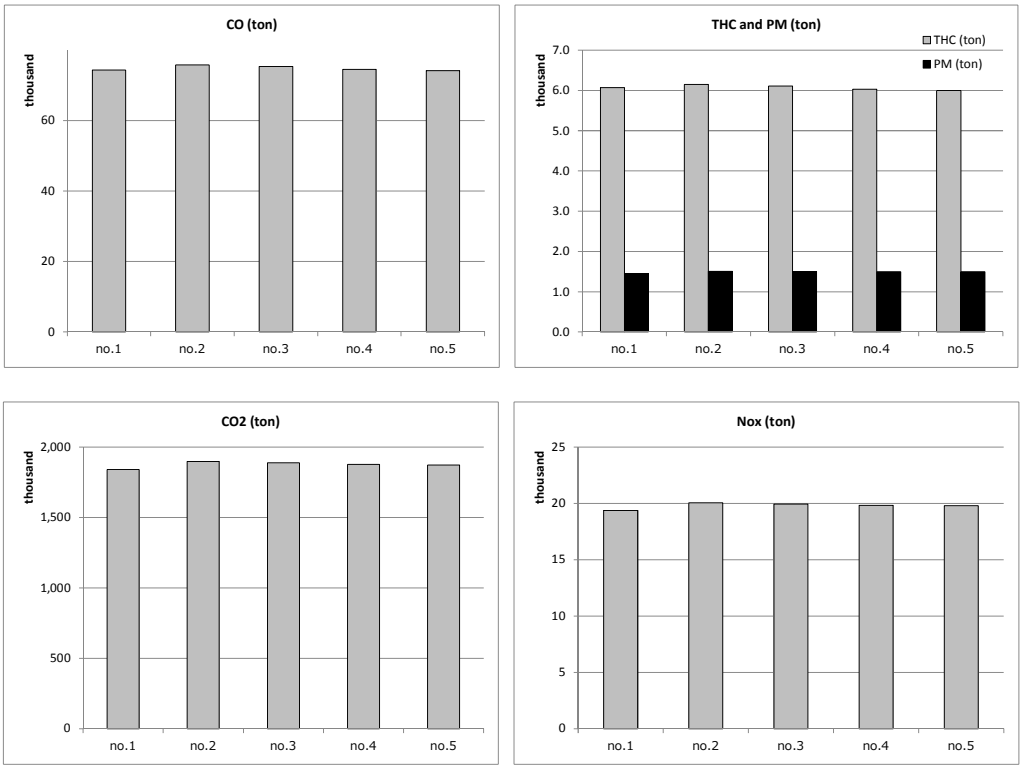
[1] The Automotive Emissions Laboratory of the Pollution Control Department (PCD), Ministry of Natural Resources and Environment, Thailand.

modern (tuk-tuk), was taken into account for deciding in favor of the emission factor used in Thailand rather than that by the Intergovernmental Panel on Climate Change (IPCC) or other countries.

$$Emission=\sum_{k} Dk \times Tk \times Efk \times 365$$

K= number of links
Dk=length of link
Tk=traffic volume by link (vehicle per day)
Efk=emission factor (g/km)

The result of emission estimations are shown in the following figure. There seems to be no remarkable differences among the alternatives.



Note: Emission is calculated as year
no.1 (Bus-Oriented), no.2 (BRT or Tram), no.3 (BRT or Tram + Elevated Transit), no.4 (Elevated Transit), and no.5 (Partially Underground Elevated Transit)
Source: PPUTMP Project Team

Figure 6.7-2 Estimation of Vehicle Emission in 2035

Based on the above, a comparative evaluation of the 5 alternatives was undertaken and Alternatives 1 and 5 obtained the same scores. However, Alternative 5 was evaluated to be better than Alternative 1 since an elevated transit is considered to be more eco-friendly in light of further expansion of public transportation in the future.

Table 6.7-4 Evaluation of Air Pollutants and GHG Emission

	Bus-Oriented	BRT or Tram	BRT or Tram + Elevated Transit	Elevated Transit	Partially Underground Elevated Transit
Air Pollutants (THC, CO, and PM)	4	1	2	3	5
GHG emission (CO2 and NOx)	5	1	2	3	4
Total Point	9	2	4	6	9
Evaluation	**4**	**1**	**2**	**3**	**5**

Source: PPUTMP Project Team

b) Decrease in Traffic Accidents

The presence of mixed traffic along with pedestrians is one of the causes of traffic accidents. In this regard, Alternative 5 (partially underground elevated rail transit) is the safest alternative, because there is no mixing with vehicular traffic at all; Alternative 4 (elevated rail transit), Alternative 3 (tram + elevated rail transit) and Alternative 2 (tram/BRT) have exclusive lanes but they mix with traffic at intersections. Alternative 1 (bus) is the system operating completely in traffic mix with other vehicles.

c) Natural and Social Environmental Impacts

The impacts on natural and social environments cannot be estimated quantitatively. Consequently, the evaluation is based on a qualitative assessment at this stage due to lack of detailed and fixed information. As mentioned above, the levels of impacts caused by road construction are the same among the five alternatives. On the other hand, in comparing these alternatives, some differences could be recognized. For instance, noise and vibration were found to have a slight difference between aboveground and underground during construction and vehicle operation. Accordingly, Alternative 5, which supposes to take underground alignment partially, could be judged as having less impact compared to the other four alternatives.

Other expected impacts are seen to happen only during the construction period but these can be mitigated by taking appropriate countermeasures. Such negative impacts are assumed generally to be the same among the five alternatives except for the involuntary resettlement. The impact of resettlement is dependent upon the size of required land for the project. In this case, the size of resettlement will be determined by the type of public transportation, i.e., the type of vehicle yard, since the main alignments are basically the same among the alternatives and the main route shall be within right of way. Therefore, Alternative 5 was assessed to make less impact since the yard could be underground and resettlement would not be required. Meanwhile, Alternative 4 was considered to need a larger scale of resettlement since the yard of elevated vehicles shall require a space in a restrictive area close to the alignment. Other alternatives might select less impact land for their yard. Alternatives 1, 2 and 3 are comparatively evaluated as to the required size of land to accommodate their vehicles. Buses tend to require more land than trams and elevated transit because of their smaller capacity compared to the two, and thus more bus units would require a bigger yard.

[Natural Environment]

Construction and Operation Period
- Land Use

[Social Environment]

Construction and Operation Periods
- Noise and Vibration

Construction Period
- Water Pollution
- Soil Pollution
- Waste
- Involuntary Resettlement
- Local Economy (Employment and Living Livelihood)
- Existing Social Infrastructures and Services
- Infectious Diseases (HIV/AIDS)

Consequently the five alternatives were comparatively evaluated on the basis of three items:

"Noise and Vibration", "Involuntary Resettlement", and "Other Impacts upon Natural and Social Environments". The results are shown in the following table:

Table 6.7-5 Evaluation of Impacts upon Natural and Social Environments

	Bus-Oriented	BRT or Tram	BRT or Tram + Elevated Transit	Elevated Transit	Partially Underground Elevated Transit
Noise and Vibration	1	1	1	1	2
Involuntary Resettlement	2	3	4	1	5
Others Impacts on Natural & Social Environment	1	1	1	1	1
Total Point	4	5	6	3	8
Evaluation	**2**	**3**	**4**	**1**	**5**

Source: PPUTMP Project Team

(4) Economic Aspects:

1) Investment Cost

Investment cost is calculated as shown below. The conversion to economic price is set as a summary economic cost excluding the considerable amount of Value Added Tax (VAT).

Table 6.7-6 Investment Cost (Financial and Economic Prices)（unit: million USD)

Case	Financial	Economic
Road	**2432.0**	2,210.9
Bus	**233.9**	212.6
BRT or Tram	**983.4**	894.0
Tram & Elevated Transit	**1729.0**	1,571.8
Elevated Transit	**2263.0**	2,057.3
Elevated Transit (partially underground)	**2968.3**	2,698.5

Source: PPUTMP Project Team

a) Cost-Benefit Ratio

Six cases including "Do Nothing" case are under consideration as alternatives of the master plan and each alternative is evaluated economically.
The result of the economic analysis is shown below. The income level of Phnom Penh is estimated to be higher by about 2.5 times than that for the whole country, according to the Cambodia Socio-economic Survey.

Table 6.7-7 Result of Economic Evaluation in case of Time Value (national value*2.5 times)

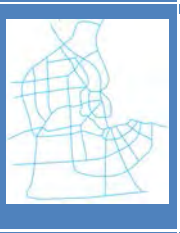
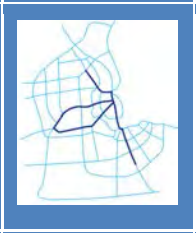
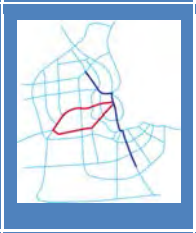
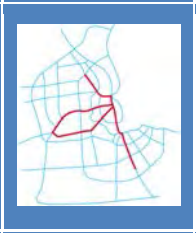
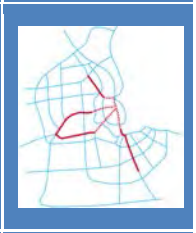
	Only road (newCase-5)	Only bus (Alt. 1)	Bus and Tram (Alt. 2)	Bus, Elevated Transit and Tram (Alt. 3)	Bus and Elevated Transit (Alt. 4)	Bus, Elevated Transit and partially underground (Alt. 5)
NPV(million USD)	1,515	1,694	1,012	833	777	614
B/C	3.3	3.2	1.8	1.5	1.4	1.3
EIRR	39%	40%	26%	22%	20%	18%

Note: NPV= Net Present Value, EIRR= Economic Internal Rate of Return
Source: PPUTMP Project Team

(5) Summary of Evaluation

Based on the above analysis, the evaluation summary by four aspects is prepared in the table below.

Table 6.7-8 Summary of Evaluation

Evaluation Factor \ Alternative		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
						
		Bus-Oriented + 2035 Road Network +Supporting Measures	BRT or Tram + 2035 Road Network +Supporting Measures	BRT or Tram + Elevated Transit + 2035 Road Network +Supporting Measures	Elevated Transit + 2035 Road Network +Supporting Measures	Partially Underground Elevated Transit + 2035 Road Network +Supporting Measures
Urban Transport Aspects	Traffic Congestion Rate and Travel Speed in the city center /Decrease of Vehicle-km and Vehicle-hour			✓	✓	✓
	Degree of Mobility		✓	✓	✓	✓
	Consideration for Transportation Poor		✓			
			↓	↓	↓	↓
Urban Planning Aspects	Harmony with Urban Scenery		✓	✓		✓
	Contribution to the Urban Vitality/ Impact to the Tourism		✓	✓	✓	✓
			↓	↓		↓
Environmental Aspects	Decrease of Air Pollutants and GHG Emission					✓
	Decrease of Traffic Accidents					✓
	Social Environmental Consideration			✓		✓
Economic Aspects	Investment Cost/ Cost-Benefit Ratio			✓		
				↓		↓
Overall Evaluation				✓		✓

6.7.3 Overall Evaluation

Based on the evaluation of the 4 aspects, the 2 highest scoring alternatives are examined for the overall evaluation.

Table 6.7-9 Overall Evaluation

	Tram + Elevated Rail Transit	Partially Underground Elevated Rail Transit
Urban Transport Aspects	High mobility and easy to adopt the staging	Lowest negative impact in terms of urban transport performance such as volume-capacity ratio and vehicle-km
Urban Planning Aspects	Match to the Urban Scenery and has great impact to the tourism	Less impact as the urban vitality tool
	Trigger of urban vitality with the development of human and environmentally friendly transit mall along Monivong. (Pedestrian + Tram + Bus)	Trigger of urban vitality with the development of human and environmentally friendly Monivong. (Pedestrian + Bus)
Urban Environmental Aspects	Relatively environmentally friendly urban transport system	Most environmentally friendly urban transport system among 5 Alternatives
Economic Aspects	Reasonable investment cost and adequate cost-benefit ratio	High investment cost and low but feasible cost-benefit ratio
Other Aspects	Public transport becomes symbol of PPCC	Possible to share with private car traffic
	Necessary to share public transport oriented consciousness in the early stage	Possible to share public transport oriented consciousness step by step
Conclusion	**Project Team proposes the Alternative 5 (Partially Underground Elevated Rail Transit + Road Network + Traffic Management Measures)**	
	Reasons: Environmentally friendly system, has great potential of triggering the City's vitality and making Phnom Penh more appealing as an environmentally friendly compact city to the world. And, it is possible to share public transport oriented consciousness step by step.	

Source: PPUTMP Project Team

6.8 Proposed 2035 Urban Transport Master Plan

It is necessary to perform "to shift from a private-oriented urban transport system to a well-balanced system of public and private transport and a combination of road, public transport and traffic management", which is the mission of the master plan, for sustaining the urban vitality and minimizing the urban transport demand of the estimated 3 million people in PPCC in 2035.
In order to realize this mission, there should be balanced planning of the components of the master plan, between infrastructure development and transport demand management, considering the urban environment. This master plan should well-consider the above planning concept and the urban transport system (main three components) of the master plan which are briefly explained below and illustrated in Figure 6.8-1.

(1) Public Transport System

Rail transit system is planned at the highest transport demand along four transport corridors with bus system and para-transit as feeders of the rail transit. Development of the mode interchange area, which is a transfer point between modes, is one of the most important factors for convenient use of the public transport. In this master plan, several types of mode interchange areas are developed depending on the type and number of modes, volume of the transport demand and land use.
The existing railway system and water transport will be used for the new urban transport system in PPCC.

(2) Road System

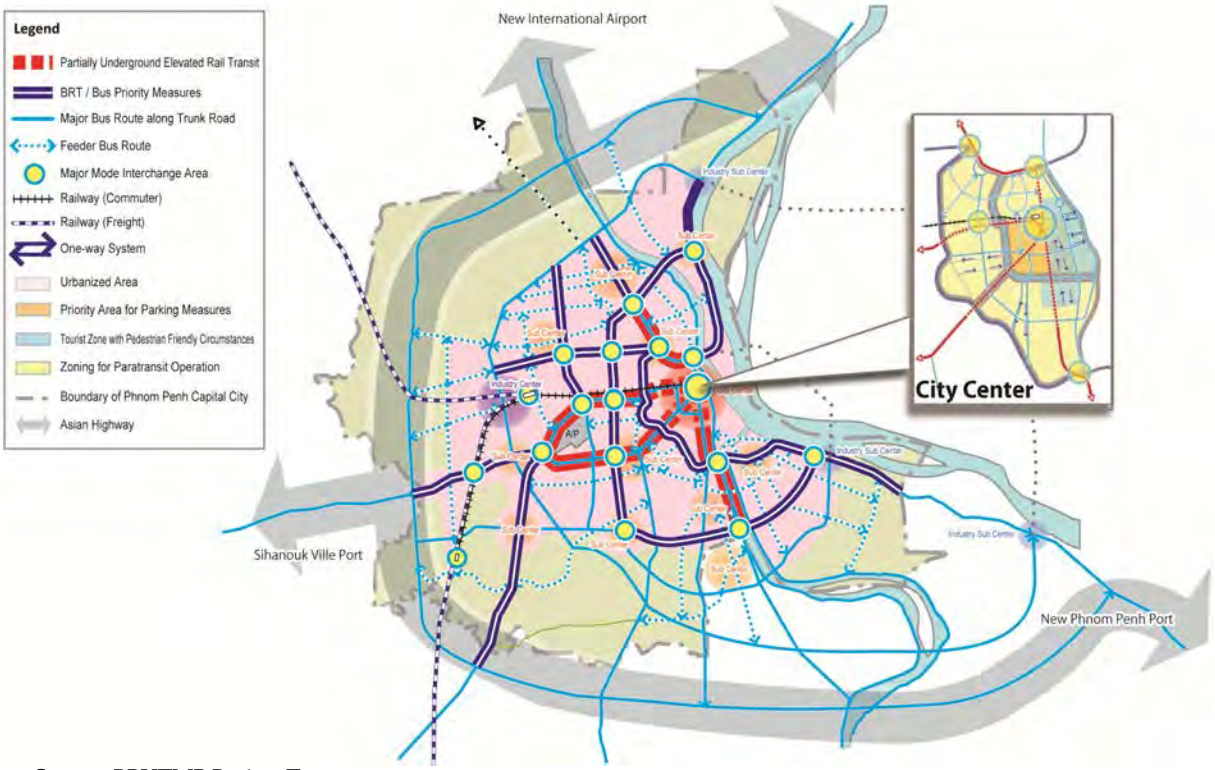
To complete the radial-ring trunk road network pattern and to guide the appropriate urbanization in the suburban area, road development is planned considering the urban environment.

(3) Traffic Management

To maximize use of the limited urban transport space, to provide convenient public transport and to develop comfortable pedestrian spaces, traffic management measures including traffic demand management schemes such as parking measures and development of high-quality pedestrian environment are introduced into the city center.

Commodity flow and environmental/social considerations, though not presented in the 2035 master plan concept in Figure 6.8-1, are also important components that support the master plan.

For a better understanding of the master plan, an outline of the 2035 urban transport master plan is provided in the following sections of the report: “6.8 Proposed 2035 Urban Transport Master Plan”, “6.9 Master Plan Components by Sector” and “6.10 Roadmap”.



Source: PPUTMP Project Team

Figure 6.8-1 Conceptual Picture of the Proposed 2035 Urban Transport Master Plan

6.9 Master Plan Components by Sector

The goal of this master plan is "to sustain Phnom Penh's vitality and have a well-maintained urban transport environment using the limited transport facilities effectively". This is based on the mission "to shift from a private-oriented urban transport system to a well-balanced system of public and private transport and a combination of road, public transport and traffic management". Therefore, the planning policy of the sector plan is to prioritize infrastructure development (hardware: increase in transport capacity) within the capability of the city's urban environment and financial state and with the well-balanced use of traffic demand management (software: decrease in traffic demand).
An outline of the sector plan is shown in Table 6.9-1.

Table 6.9-1 Master Plan Components by Sector

Goal and Target	Strategy	Sector/Component	
GOAL and MISSION -To Achieve the Goal (2035 Urban Vision and Urban Structure), the Mission of the Urban Transport Master Plan is Improving the Mobility and Emerging the Urban Development Potential in Phnom Penh City- Target 1: Share of Public Transport in 2035 is more than 30%. Target 2: Volume-capacity Ratio in the city center is less than 1.0. Target 3: Travel speed in the city center at a level higher than 20km/hour. Target 4: Decrease of Greenhouse Gas Emission of 10 % compared with "Do Nothing" Case.	Strategy 1: Formulation of urban transport system with high mobility and serves the needs of the transportation poor	Public Transport System	Introduction of trunk public transportation system with related countermeasures such as mode interchange area development
			Countermeasures for para-transit
			Effective use of existing public transport such as the railway and water transport
	Strategy 2: Formulation of physical framework of urban transport system and creation of smooth connection between major cities in the Mekong Sub-region	Road System	Effective use of road space in the city center such as flyover constructions
			Completion of radial-ring pattern trunk road network
			Construction of new roads in the newly developed suburban area
	Strategy 3: Maximize the use of existing transport spaces including underground and elevated spaces in the city center	Traffic Management	Introduction of traffic management schemes for effective use of road space in the city center such as the one-way system
			Parking measures
			Development of comfortable pedestrian environment
			Driver's education and traffic enforcement
			Traffic Demand Management (TDM) including mobility management
	Strategy 4: Efficient traffic flow for commodity	Commodity Flow	Allocation of commodity flow facilities
			Formulation of commodity flow network
			Roadside loading/unloading of commodities in collaboration with traffic management
	Strategy 5: Environmental/ social considerations and establishing appropriate urban transport-related organizations are the fundamental concept of the master plan	Environmental and Social Considerations and others	Prevention of deterioration in air quality/noise and mitigation of CO2 emissions Improvement of urban parks/greenery and keeping diversity of the ecosystem in the suburban area
			The keys of materialization and sustainability of the Master Plan are the establishment of an appropriate urban transport-related organization, considering financial mechanism including private participation and the participation of many stakeholders.

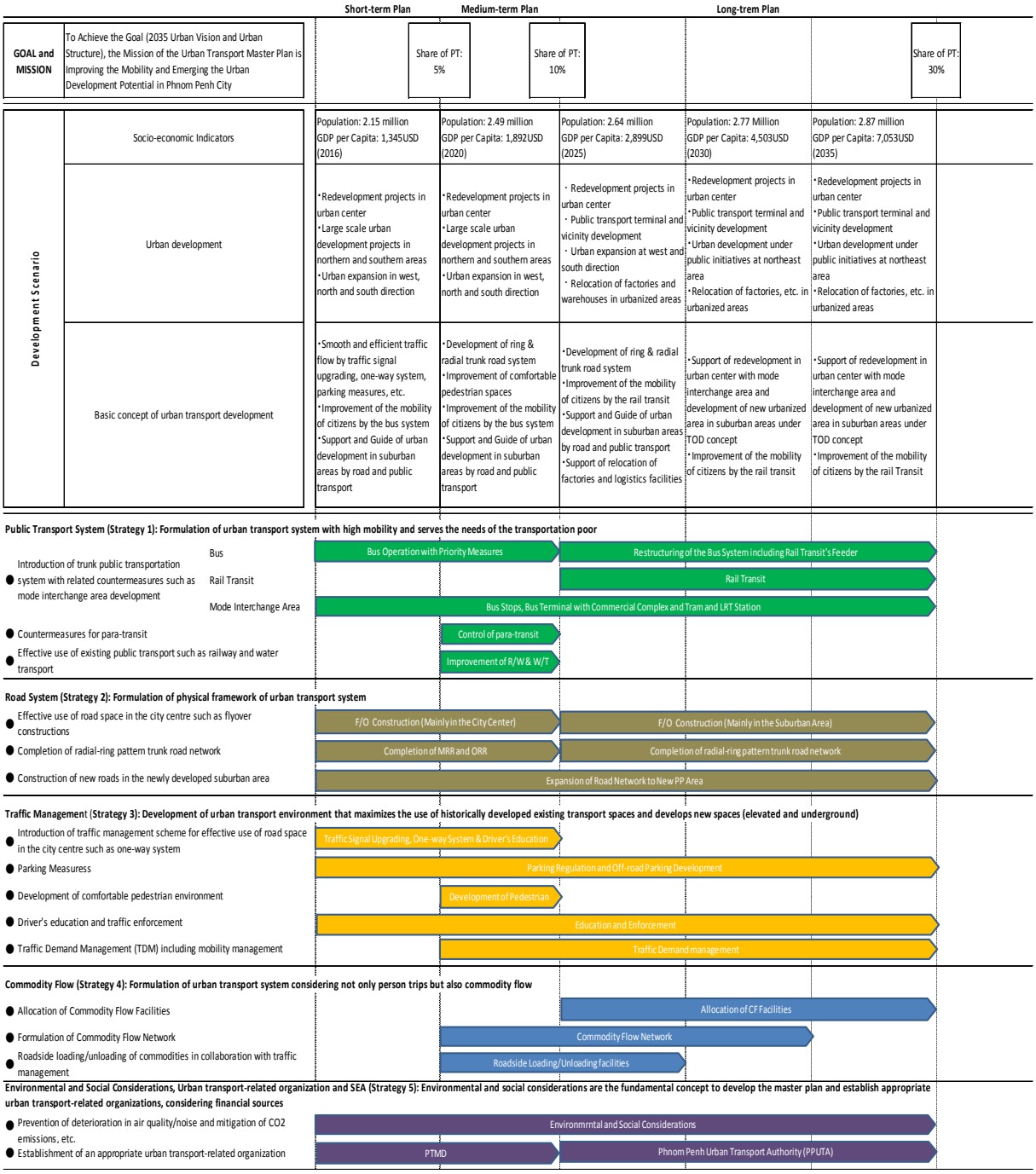
Source: PPUTMP Project Team

6.10 Roadmap

The roadmap in this project shows the process of how to materialize the 2035 master plan considering the coordination between master plan sectors. Actually, the project has three time frames, namely, short term (year 2016), medium term (year 2020) and long term (year 2035).
The short-term and long-term actions are clear, i.e., the short-term activities are the immediate actions to cope with the current problems/issues using more effective and cheaper countermeasures such as traffic management measures, while the long-term activities are definitely for the materialization of the goal of the master plan.
Therefore, the importance of the roadmap in this project is to clearly define the medium-term actions in relation to the short-term and long-term actions to materialize the goal of the master plan without any discrepancy.
Main points of the medium-term roadmap are as follows:

a) In terms of public transport, how to ensure the transition from bus to rail transit is as seamless as possible.
b) How to complete the radial-ring road network pattern before the medium term (year 2020).
c) How to effectively implement the traffic management measures to cope with the urgent urban transport problems/issues.
d) How to adopt the urban transport-related organizations in line with the development of the trunk public transport system.

Based on the above discussion, the master plan roadmap is illustrated in Figure 6.10-1.



Note: R/T= Rail Transit, R/W= Railway, W/T= Water Transport, CBD= Central Business District, F/O= Flyover, MRR= Middle Ring Road, ORR= Outer Ring Road, PTMD= Public Transport Management Division, and PPUTA= Phnom Penh Urban Transport Authority

Source: PPUTMP Project Team

Figure 6.10-1 Roadmap for Urban Transport Master Plan in PPCC