PREPARATORY SURVEY FOR NATIONAL ROAD NO. 5 REHABILITATION PROJECT IN THE KINGDOM OF CAMBODIA

FINAL REPORT

OCTOBER 2012

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS INTERNATIONAL

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12-200

Exchange Rate
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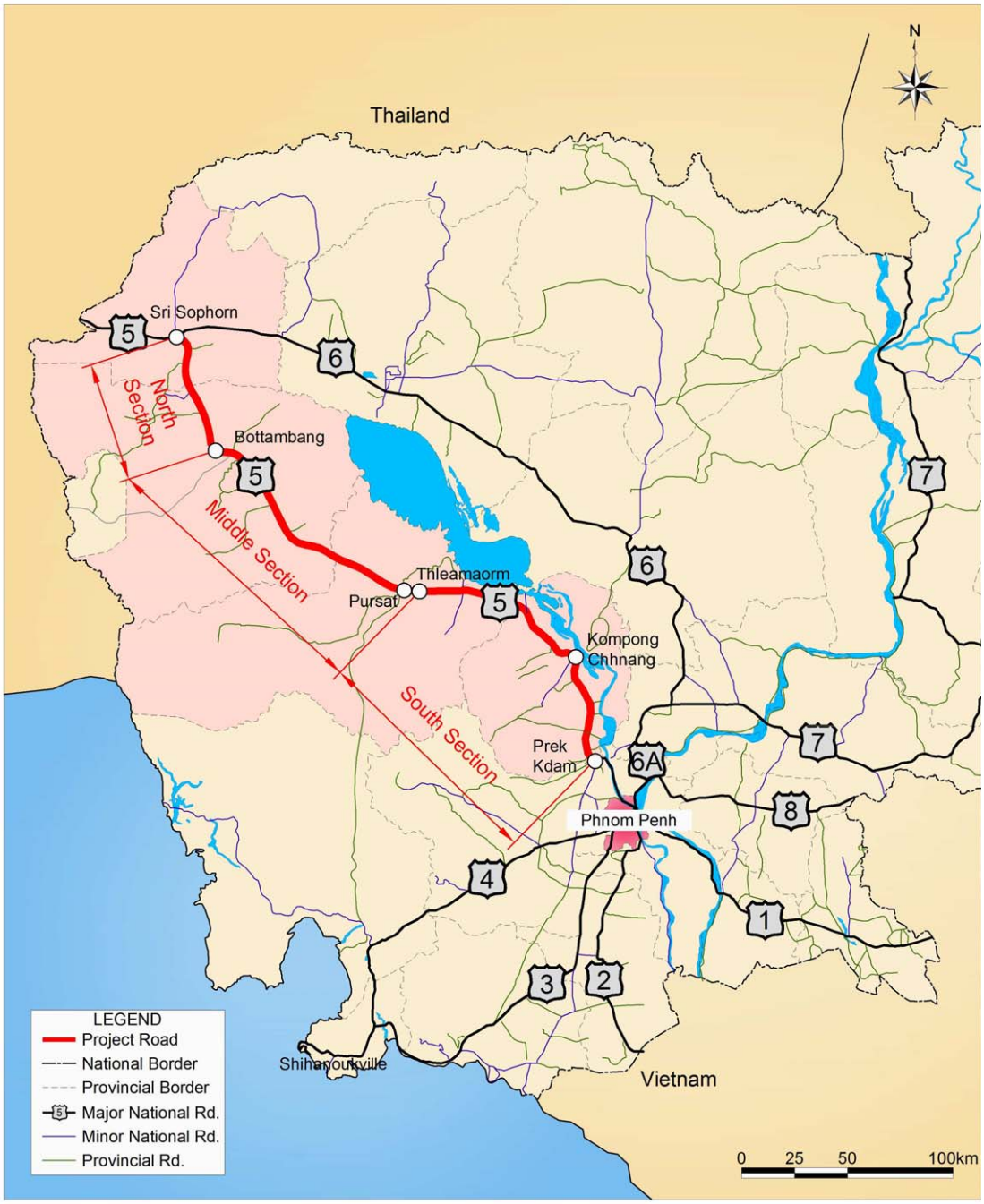
(As of Aug. 2011)



Location Map

** The name of the city of 'Sisophon' was officially changed to 'Serei Saophoan' after this Survey had started, and finally to 'Sri Soporn' during the loan processing. In preparing the Final Report, the Survey Team corrected from 'Sisophon' to 'Sri Sophorn' as much as possible. However, there may still remain the word 'Sisophon' and 'Serei Saophoan'. The readers are kindly requested to interpret that 'Sisphon', 'Serei Saophoan' and 'Sri Sophorn' refer the same city.*

SUMMARY

1. Outline of the Project

- The Project consists of three components:
  (i) Widening Battambang – Sri Sophorn Section (47.0km) of National Road No. 5 (NR 5) into 4 lanes
  (ii) Construction of Battambang Bypass (23.1km) and Sri Sophorn Bypass (13.4km) as 2-lane roads.

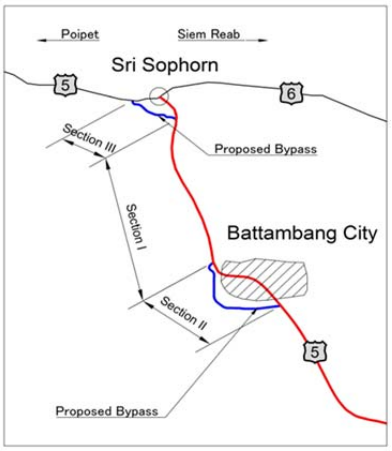


Figure 1 Project Road

2. Objective of the Preparatory Survey

- Objectives of the Preparatory Survey are twofold:
  (i) Evaluate the current conditions of the North, South and Middle Section (see the Location Map) and evaluate the priorities for improvement.
  (ii) Prepare the data and information required for appraisal of loan project.

Figure 2 Location Map

3. Importance of National Road No. 5

- NR 5 plays important role in Cambodia and ASEAN:
  - NR 5, together with NR 1, constitutes a part of ASEAN Highway No. 1 connecting Bangkok – Phnom Penh – Ho Chi Minh City.
  - This corridor is called 'Southern Economic Corridor of GMS (Greater Mekong Sub-region).
  - Improvement of NR 5 is expected to contribute to development of cooperation in GMS as well as development of socio-economic activities in Cambodia.

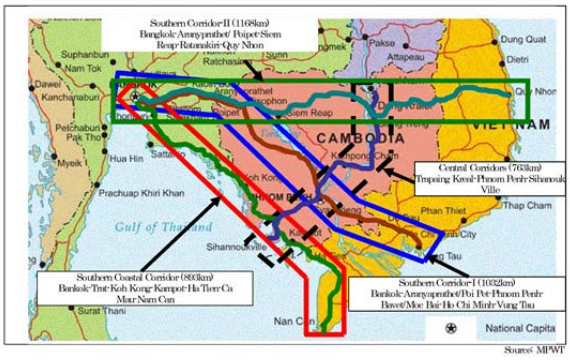


Figure 3 GMS Economic Corridor

4. Existing Conditions of NR 5 and Its Problems

- The existing NR 5 is 2-lane road which imposes hazardous traffic condition.
- Pavement is DBST which is vulnerable to heavy traffic and cannot support growing economic activities.
- Fragile pavement is also imposing the Government of Cambodia heavy financial burden of maintenance.
- Inundation frequently occurs and hampers smooth and stable transport.

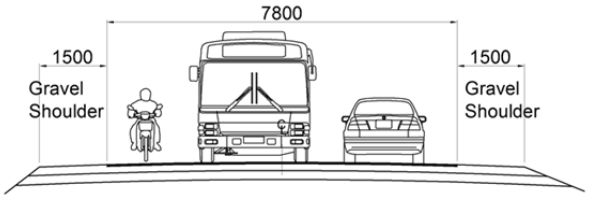


Figure 4 Typical Cross Section of North Section

Figure 5 Hazardous Traffic Condition

Figure 6 Damaged Pavement

5. Future Traffic Demand

- Future traffic demand on NR 5 was forecasted based on the results of surveys on current traffic characteristics and future economic growth.
- Vehicle registration is estimated to reach around 6.5 million in Year 2030 owing to rapid economic growth of Cambodia.
- Traffic volume on the North, Middle and South Sections are estimated as shown in Table 1.
- Traffic volume in Year 2030 exceeds traffic capacity on the North Section and approaches to the capacity on the South Section.

Table 1 Estimated Traffic Volume

(Unit: pcu)

Section	Year			
	2011	2016	2021	2030
North	8,453	12,356	17,812	25,540
Middle	6,071	8,232	11,368	15,899
South	8,644	11,519	15,735	21,164

6. Priority of North, Middle and South Sections for Improvement

- Road widths of North Section and South Section are similar with each other while the road width of Middle Section is slightly wider than those of North and South Sections.
- Urgent repair of the South Section is on-going under financial assistance of ADB (RAMP).
- Considering mainly the urgent repair of RAMP, the priority of the North Section is evaluated to be higher than that of the South Section, although the both sections needs to be urgently improved.

7. Priority of Bypass

- Battambang Bypass and Sri Sophorn Bypass are evaluated to have higher priority than Kampong Chhnang Bypass since from viewpoint of continuity of traffic flow and the project implementation/ supervision.

8. Study of Bypass Route

(1) Battambang Bypass

- Six alternative routes were studied for Battambang Bypass.
- Alternative routes were evaluated mainly from viewpoints of number of houses/household to be relocated, impact to natural environment of especially Tonle Sap Lake and Tonle Sap River, and future urban development, as well as traffic flow.
- After consultation among MPWT, Provincial Government of Battambang, affected people and JICA Study Team, Alternative JICA-1 was selected as the most preferable route.
- After further study and consultation the route as shown in Figure 8 was finally selected.

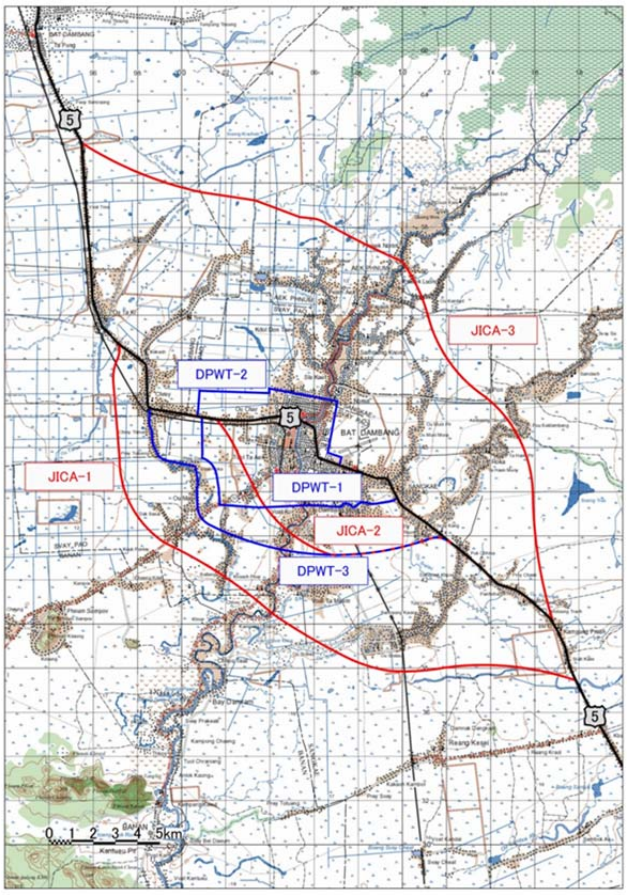


Figure 7 Alternative Routes of Battambang Bypass

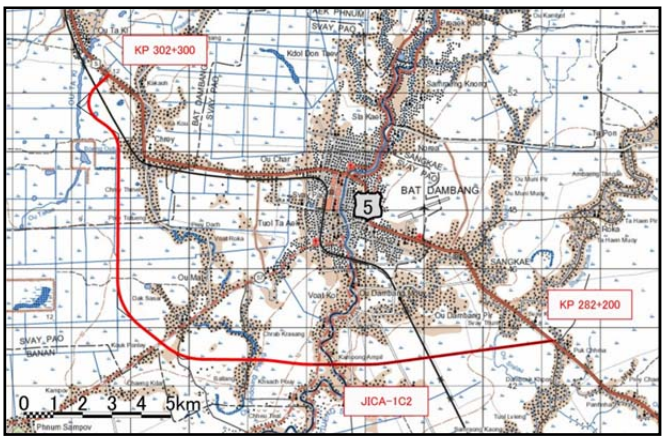


Figure 8 Finally Selected Route of Battambang Bypass

(2) Sri Sophorn Bypass

- Sri Sophorn Bypass was planned to avoid resettlement of people in the city of Sri Sophorn.
- Alternative routes as shown in Figure 9 were evaluated.
- With consultation among MPWT, Provincial Government of Banteay Meanchey, and JICA Team, Alternative JICA-3 was adopted.

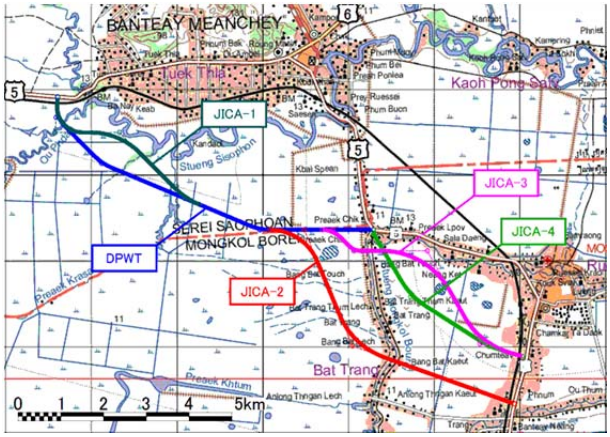


Figure 9 Alternative Routes of Sri Sophorn Bypass

9. Design of Widening of North Section and Bypasses

(1) Design of Widening of North Section

- Three alternatives of cross section were studied
  - (i) Full 4-lane with 3m-wide median division and 3m-wide paved shoulder,
  - (ii) 4-lane with 0.5m-wide median and 3m-wide gravel shoulder
  - (iii) Opposed 2-lane plus slow vehicle lanes of 2.5m wide on the both sides
- In the all alternatives, 2.5m-wide parking space was planned in urbanized sections.
- The above alternatives were compared from viewpoints on the following aspects:
  - (i) Standard of ASEAN Highway and Cambodian Road Design Standards
  - (ii) Traffic Capacity
  - (iii) Traffic Safety
  - (iv) Resettlement and other social impacts
  - (v) Project Cost
- After many discussions between MPWT, MEF, JICA and JICA Survey Team, Alternative (ii) was selected. Figures 10 and 11 shows typical cross section for rural and urbanized section, respectively.
- Figure 12 shows perspective view of the widened NR 5.

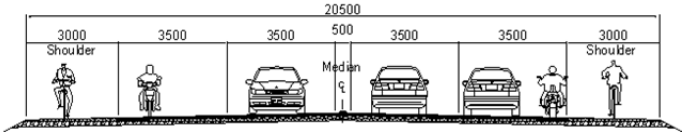


Figure 10 Adopted Typical Cross Section of Rural Section

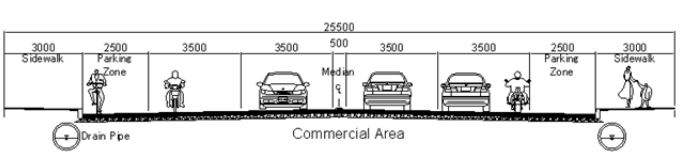


Figure 11 Adopted Typical Cross Section of Urban Section

Figure 12 Perspective View of Widened NR 5

(2) Design of Bypass

- Considering the estimated traffic which will divert to the bypasses, opposed 2-lane cross section was proposed by the JICA Survey Team and was agreed among MPWT, MEF and JICA.
- Same cross section is to be used in both Battambang and Sri Sophorn Bypasses considering the estimated traffic volumes.
- Figure 13 shows the adopted typical cross section of bypasses.

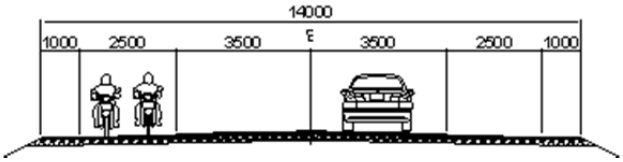


Figure 13 Typical Cross Section of Bypasses

10. Project Cost

- Project cost is estimated as shown in Table 2.

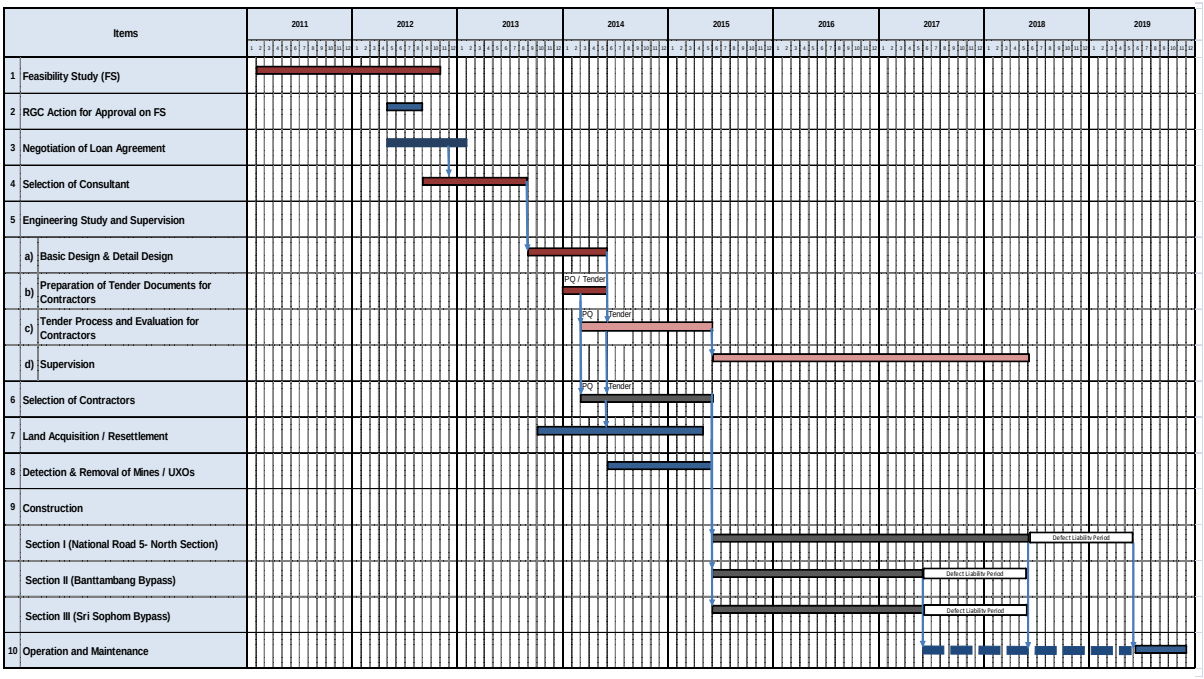
Table 2 Estimated Project Cost

Items		Amount (USD million)	Items		Amount (USD million)
JICA Portion			**RGC Portion**		
1-1	Construction cost		2-1	Land Acquisition and Resettlement Cost	***
	Section I (North Section of NR 5)	***	2-2	Utilities Relocation / Removal / Protection Cost	***
	Section II (Battambang Bypass)	***	2-3	Detection and Removal Cost of Mines and UXOs	***
	Section III (Sri Sophorn Bypass)	***	2-4	Price Escalation	***
	Total of Construction Cost	***	2-5	Contingency	***
1-2	Consulting Services	***	2-6	Employer's Administration Cost	***
1-3	Price Escalation for above	***	2-7	Taxes	***
1-4	Contingency	***			
	Total of Project Cost (JICA Portion)	***		**Total of Project Cost (RGC Portion)**	***
Grand Total			***		

11. Implementation Schedule

- Table 3 shows the Implementation Schedule. The Project is expected to be completed in Year 2018, if the procedures of procurement consultant for detailed design and construction supervision will be started in September 2012.

Table 3 Implementation Schedule



12. Project Evaluation

- Based on the improvement of traffic condition and estimated traffic cost, economic internal rate of return (EIRR) and other economic indicators were calculated as shown in Table 4.
- Sensitivity analysis shows that even in the most unfavorable scenario with 10% increase in the Project cost and 10% decrease in the benefit, EIRR is calculated to be 20.2%.
- With EIRR larger than 20%, the project is evaluated to be economically viable.

Table 4 Economic Parameters

Indicator	Result
EIRR (%)	22.4
B/C	3.08
NPV（USD Million）	***

Table 5 Sensitivity Analysis

Case	EIRR
Base Case	22.4
Investment Cost +10%	21.3
Benefit -10%	21.2
Investment Cost +10%, Benefit -10%	20.2

13. Environmental and Social Consideration

- According to the Cambodian legislations on EIA, EIA is not required for the Project since the total length of Project road is less than 100km.
- However, the project is anticipated to require large number of resettlement of families and preparation of EIA report and Resettlement Action Plan (RAP) are required according to the JICA's Guidelines for Environmental and Social Consideration'.
- EIA report and RAP were prepared by MPWT with assistance of JICA Survey Team and were submitted to JICA.
- Preliminary survey on Affected Households (AHs) showed that 2,265 households are affected.
- In the stakeholder meetings, there were very few opinion of oppositions to resettlement for the Project.

Table 6 Affected Households

Province	No. of AHs by Section			Total (AHs)
	National Road 5	BTB Bypass	BMCH Bypass	
Banteay Meanchey Province	**644**	**0**	**150**	**794**
Mongkol Borei District	644	0	108	752
Krong Sri Sophorn	0	0	42	42
Battambang (BTB) Province	**964**	**507**	**0**	**1,471**
Thma Koul District	964	107	0	1071
Krong Bat Dambang	0	235	0	235
Sangkae District	0	165	0	165
Total (the Project)	**1,608**	**507**	**150**	**2,265**

14. Conclusion and Recommendation

(1) Conclusion

- Improvement of Battambang – Sri Sophorn Section of Natinal road No. 5 and construction of Battambang Bypass and Sri Sophorn Bypass are justified considering the following aspects:
  - There is no strong opposition to the Project among the stakeholders, including the people who are anticipated to be relocated.
  - The Project is expected to yield economic benefit such as EIRR of 22%
  - No significant adverse impact on natural and living environment of the Project Area is anticipated.

(2) Recommendation

- Improvement of Battambang – Sri Sophorn Section of NR 5 and construction of Battambang Bypass and Sri Sophorn Bypass is recommended to be implemented.
- MPWT is recommended to employ competent consultants for the consultat services of detailed design/assistance for procurement of civil works/construction supervision to minimize risks possible to occur during construction.
- MPWT is recommended to request to JICA for technical assistance for implementation of Yen loan project.
- Survey on improvement of Prek Kdam – Thlea Ma'am Section and construction of Kampong Chhnang Bypass need to be urgently studied.

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LIST OF ABBREVIATIONS (1/2)

AC	: Asphalt Concrete
ADB	: Asia Development Bank
AP	: Affected People
ASEAN	: Association of South East Asian Nations
BC	: Beginning Curve
Br	: Bridge
CBR	: California Bearing Ratio
COM	: Council of Ministers
CRIP	: Cambodia Road Improvement Project
CS	: Construction Stage
DBST	: Double Bituminous Surface Treatment
DE	: Department of Environment
DEIA	: Department of Environmental Impact Assessment
DPWT	: Department of Public Works and Transport
EC	: End Curve
EFRP	: Emergency Flood Rehabilitation Project
EIA	: Environmental Impact Assessment
GDP	: Gross Domestic Product
GMS	: Grater Mekong Subregion
HV	: Heavy Vehicle
IEIA	: Initial Environmental Impact Assessment
IG	: Welded Steel Plate I Girder
IP	: Intersection Point
IRC	: Inter-Ministerial Resettlement Committee
Jct.	: Junction
JICA	: Japan International Cooperation Agency
kN	: kilo Newton
KP	: Kilometer Post
LV	: Light Vehicle
MAFF	: Ministry of Agriculture, Forestry and Fisheries
MC	: Motor Cycle
MEF	: Ministry of Economic and Finance
MLMUPC	: Ministry of Land Management, Urban Planning and Construction
MOC	: Ministry of Commerce

LIST OF ABBREVIATIONS (2/2)

MOE	: Ministry of Environment
M/P	: Master Plan
MPWT	: Ministry of Public Works and Transport
MRC	: Mekong River Commission
N.A.	: Not Applicable
NGO	: None Governmental Organization
NR	: National Road No.
OD	: Origin Destination
ODA	: Official Development Assistance
PAP(s)	: Project Affected Person(s)
PC	: Pre-stressed Concrete
PCDG	: Pre-tensioned Precast Concrete Deck Girder
PCS	: Pre-tensioned Precast Concrete Plank hollow Slab
PCU	: Passenger Car Unit
PMO	: Prime Minister's Office
PRC	: People's Republic of China
PRRP	: Primary Roads Restoration Project
PS	: Planning Stage
RAMP	: Road Assets Management Project
RAP	: Resettlement Action Plan
RC	: Reinforced Concrete
RCA	: Reinforced Concrete Arched Rib
RCDG	: Reinforced Concrete Deck Girder
RCS	: Reinforced Concrete Flat Slab
RGC	: Royal Government of Cambodia
ROW	: Right of Way
SBST	: Single Bituminous Surface Treatment
SHMs	: Stakeholder Meetings
SPT	: Standard Penetration Test
SS	: Service Stage
STRADA	: System for Traffic Demand Analysis
USDA	: United States Department of Agriculture
VCR	: Traffic Volume per Capacity Ratio

LIST OF APPENDIXES

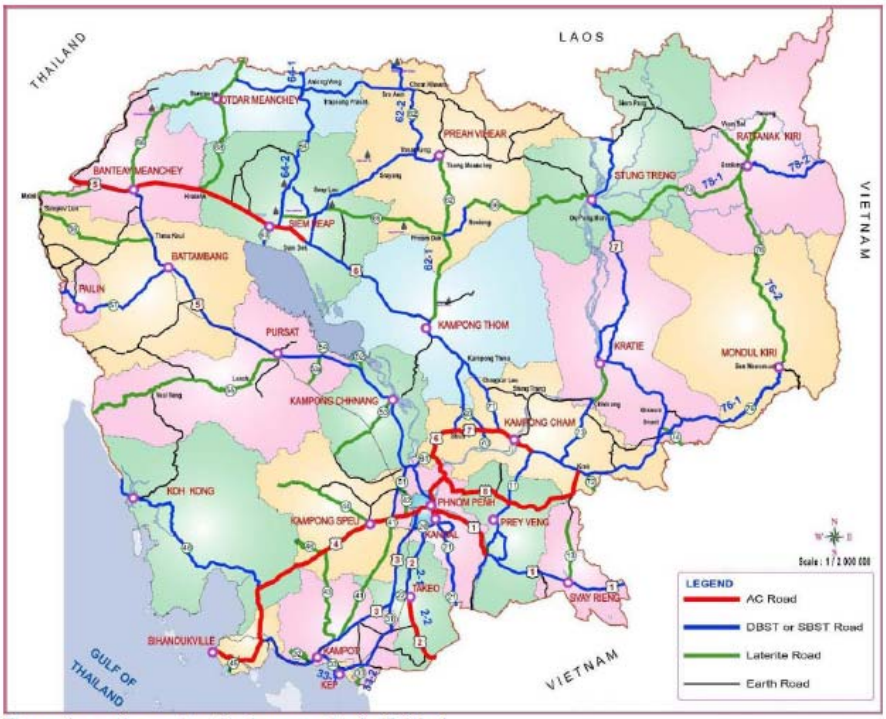
CHAPTER 1 INTRODUCTION

1.1 Background

In the Kingdom of Cambodia ("Cambodia"), the road transport accounts for around 65% of the passenger transport, for 70% of the freight transport, and plays the most important role in the domestic transport. However the most of the roads were severely deteriorated during the civil war in the 70's to 80's. Since the early 90's Royal Government of Cambodia (RGC) has been exerting strenuous effort on rehabilitation of the road network with the assistance of Japan, the United States, Australia, Asian Development Bank ("ADB") and Word Bank.

National Road No. 5 (NR 5) is the trunk road reaching Bangkok through the border between Cambodia and Thailand. It is also designated as Asian Highway A-1 or Southern Economic Corridor of GMS. The Survey Roads was damaged by the flood in 2000, and the section between Prek Kdam and Thlea ma'Am and the section between Battambang and Sri Sophorn have been temporarily repaired.

The repairs mentioned above mostly adopted DBST and the surface condition is being deteriorated, and the traffic flow has been hampered. Improvement of Southern Economic Corridor is in urgent need as known from the fact that it was designated as one of the prior projects in the 'Study on the Road Network Development in the Kingdom of Cambodia' (Master Plan Study), implemented by JICA in 2006.



Note: The section under construction is assumed to be finished

Source: MPWT

Figure 1.1-1 Surface Condition of National Roads in Cambodia (As of 2010)

Under such condition, JICA dispatched a survey team to Cambodia in November, 2010, held a series of discussions and reached agreement about a scope of the Preparatory Survey.

This Preparatory Survey (the Survey) is implemented, in view of the background as sited above, to obtain data and information required for appraisal of loan project of Japanese ODA, such as preliminary design, project cost, implementation plan, and natural and social impacts.

1.2 Objectives of the Survey

(1) The objective of the Project: The objectives of National Road No. 5 Rehabilitation Project (the Project) are as follows.

- To ensure safe and smooth means of transport
- To promote economic activity in the area along the Project Road.

(2) Objective of the Survey: The objectives of the Survey are as follows.

- To confirm the justification of the Project
- To obtain data and information required for appraisal of a loan project.

1.3 Survey Area

The Survey is to cover the section of National Road No. 5 between Prek Kdam and Sri Sophorn* (length: approximately 337 km). This road section traverses the provinces of; Kandal, Kampong Speu, Kampong Chhnang, Pursat, Battambang, and Bantey Meanchey,

** The name of the city of 'Sisophon' was officially changed to 'Serei Saophoan' after this Survey had started, and finally to 'Sri Soporn' during the loan processing. In preparing the Final Report, the Survey Team corrected from 'Sisophon' to 'Sri Sophorn' as much as possible. However, there may still remain the word 'Sisophon' and 'Serei Saophoan'. The readers are kindly requested to interpret that 'Sisphon', 'Serei Saophoan' and 'Sri Sophorn' refer the same city.*

1.4 Scope of Work

The original Scope of Work of the Survey as follows:

(1) Confirmation of the Scope of the Work

(2) Investigation and Evaluation of Existing Facilities

(3) Traffic Survey and Future Traffic Demand Forecast

(4) Aerial Photo Survey and Digital Mapping

(5) Geotechnical Investigation

(6) Environmental and Social Considerations Study, including support to MPWT in preparing EIA report and RAP and holding stakeholders meetings

(7) Evaluation of Priority Section

(8) Comparative Study of Bypass Route (around the cities of Kampong Chhnang and Battambang)

(9) Topographic Survey

(10) Preliminary Design of Roads and Bridges

(11) Project Cost Estimation and Economic Evaluation

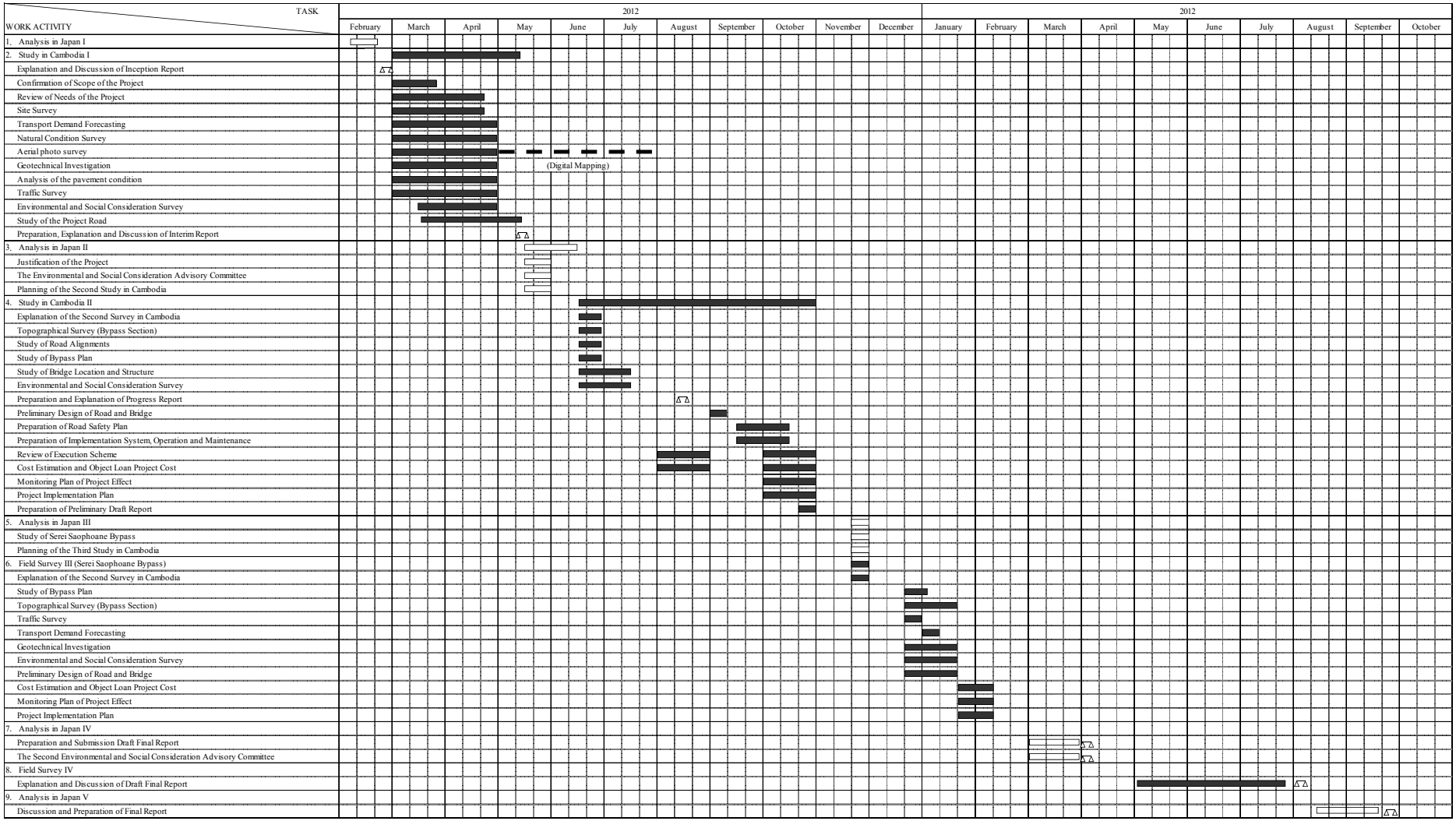
(12) Project Implementation Plan

In the 2nd Steering Committee held on 30 August 2011, study on Sri Sophorn Bypass was requested by the Cambodian side and JICA accepted this. Thus, the study on Sri Sophorn Bypass was added to the scope.

1.5 General Works Schedule

Due to the addition of Sri Sophorn Bypass to the scope, as sited above, the schedule of the Survey was revised. Table 1.5-1 shows the general schedule of the Survey after the revision:

Table 1.5-1 General Schedule of the Survey



1.6 Organization of the Survey

The organization of the Survey is shown in Figure 1.6-1.

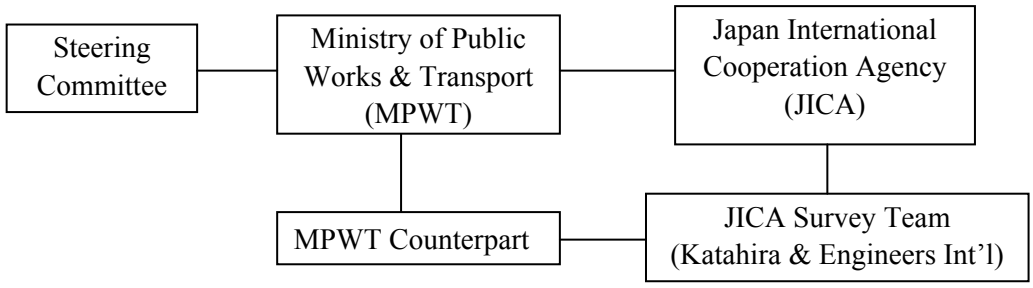


Figure 1.6-1 Organization of Survey

Members of the Steering Committee are the representatives of relevant organization of Cambodia, JICA and the Survey Team. Table 1.6-1 shows the member of the Steering Committee.

Table 1.6-1 List of Steering Committee Member

Organization	Steering Committee Member	Remarks
Ministry of Public Works & Transport (MPWT)	Secretary of State (HE Tauch Chankosal)	Chair Person
	Director General of Public Works (HE Kem Borei)	
	Director of International Cooperation (Mr. Chhim Phalla)	
	Deputy Director of Intnt'l Coop. (Mr. Kong Sophal)	
Ministry of Economy & Finance (MEF)	Representative of Department of Resettlement Department	
Ministry of Environment (MOE)	Representative of	
Banteay Meahchey Province	Director of DPWT (or his representative)	
Battambang Province	Ditto	
Pursat Province	Ditto	1st S/C only
Kampong Chhnang Province	Ditto	Ditto
Kandal Province	Ditto	Ditto
JICA	Sr. Representative, Cambodia Office (Mr. HIRATA Hitoshi)	
	Representative, Cambodia Office (Mr. MORIHATA Shigo: Up to May 2011) (Mr. EGAMI Masahiko: From June 2011)	

At the headquarter of JICA in Tokyo, Mr. KIMURA Hiroshi (up to May 2011) and Mr MIYAKE Shigeaki (from June 2011), Directors of Transport & ICT Division 2, Economic Infrastructure Department, Mr. OSHIRO Nodoka (up to June 2011) and Mr. FUKUI Takanori (from July 2011), Deputy Directors of Transport & ICT Division 2, Economic Infrastructure Department were in charge of administration of the Survey.

The members of JICA Survey Team are as listed in Table 1.6-2.

Table 1.6-2 Team Member List

No.	Name	Job Title	Firm
1	SAKURAI Tatsuyuki	Team Leader/Road Traffic Plan	Katahira & Engineers International
2	MURAKAMI Keiichi	Deputy Team Leader/Road Design	Katahira & Engineers International
3	ANTHONY GOURLEY	Road Structure Plan	Katahira & Engineers International
4	YASHIRO Shuichi	Traffic Survey/Demand Forecast / Economic Analysis	Katahira & Engineers International
5	TAKEUCHI Ryouji	Natural Condition Survey / Environnement Consideration	Katahira & Engineers International
6	SAITO Kumi	Social Consideration	Katahira & Engineers International (Seconded from Nippon Koei)
7	YAMAUCHI Masafumi	Construction Plan/Cost Estimation	Katahira & Engineers International
8	TOCHINAKA Masateru	Project Coordination/Road Designing Assistant	Katahira & Engineers International

CHAPTER 2 PROFILE OF THE SURVEY AREA

2.1 Physical Profile

(1) Geography

NR 5 starts from Phnom Penh and traverses the southwest side of Tonle Sap River and Tonle Sap Lake up to Battambang. Between Battambang and Sri Sophorn, it passes through the upstream area of Tonle Sap Lake and finally reaches the border with Thailand. The distance between the city of Sri Sophorn (the north end of the Survey Section) and Poipet (the border point with Thailand) is approximately 50km and distance between Poipet and Bangkok in Thailand is approximately 250km. Thus, NR 5 becomes the main transport route between Phnom Penh and Bankgkok.

Figure 2.1-1 Location of NR 5

(2) Topography

The ground height along the NR is, in general, around 10m above sea level or less except at some sections passing low hills as shown in Figure 2.1-2 [Also see Figures 7.1-2 (1) – (3)].

Thus, the terrain along NR 5 is generally flat.

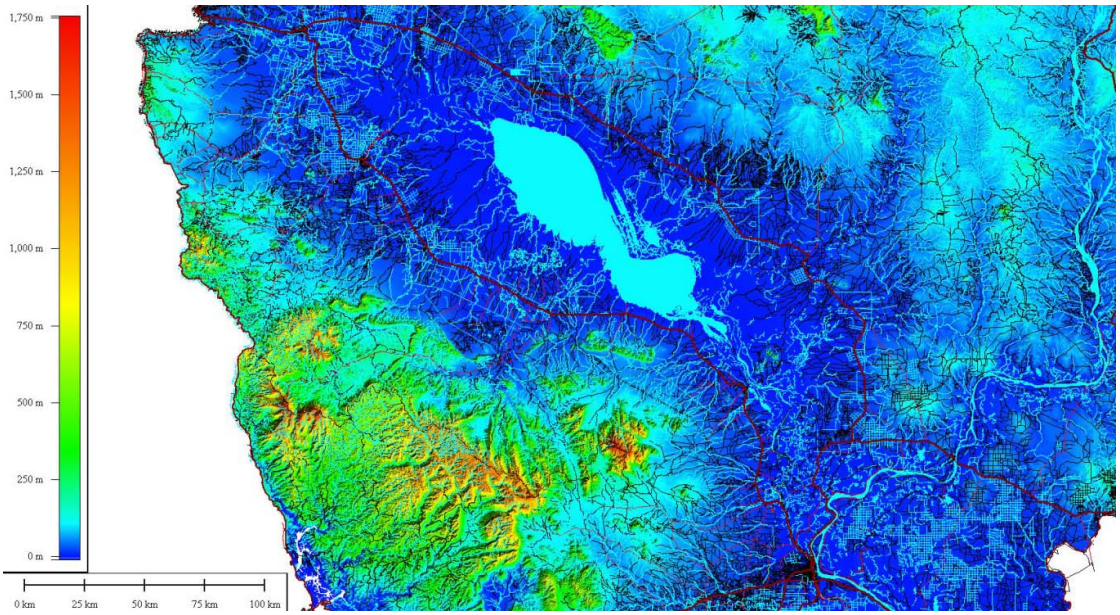


Figure 2.1-2 Topography of Survey Area

(3) Meteorology

Climate of Cambodia is influenced by the Asian Monsoon and the climate can be described as 'hot and humid' in general. Figure 2.1-2 shows annual rainfall in Cambodia. It shows that the annual rainfall of the Survey Area is in the range of 1,200 – 1,600mm/yr.

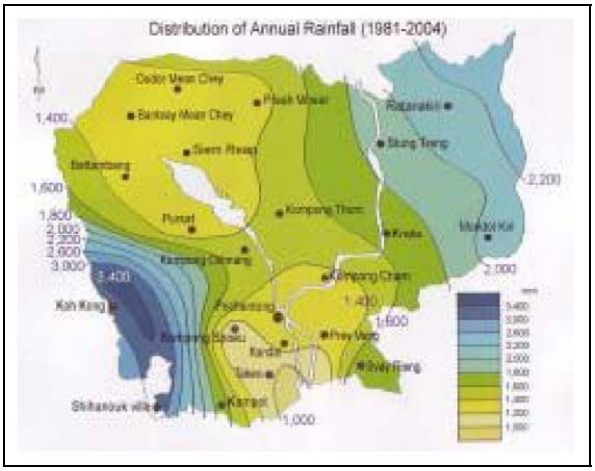


Figure 2.1-3 Annual Rainfall
(Quoted from the final report of 'the Study on the Road Network Development in the Kingdom of Cambodia, October 2006, JICA)

Figure 2.1-3 shows the monthly average rainfall and temperature measured at Pochetong, Phnom Penh. It shows that the rainy season is from May to September and dry season is from November to April. It also shows that the monthly average temperature ranges between 25 and 34 degree Celsius.

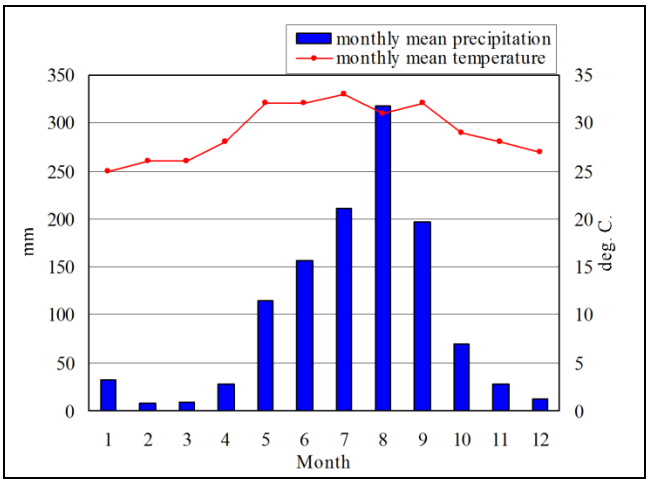


Figure 2.1-4 Average Monthly Rainfall and Temperature
(Quoted from the final report of 'the Study on the Road Network Development in the Kingdom of Cambodia, October 2006, JICA)

Table 2.1-1 shows record of monthly rainfall in Battambang Province in years 2010 and 2011, as an example. June to October are rainy months and December to February are dry months.

Table 2.1-1 Monthly Rainfall in Batttambang Province

(mm)

Year	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2010	8.3	12.0	25.2	69.9	77.3	121.2	241.9	216.6	193.3	325.2	40.5	8.3	1339.7
2011	0.0	50.8	35.1	152.7	151.5	108.0	186.8	253.2					-

Source: Department of Water Resources and Metrology, BB Province

The condition water of the area is also greatly influenced by the flood of Mekong River and Tonle Sap. The flood of Mekong River and Tonle Sap is discussed in Chapter 6.

Table 2.1-2 shows the temperature of Battambnag Province in years 2010 and 2011. March to May are hot months and October to December are cool months.

Table 2.1-2 Maximum and Minimum Temperaturein Battambang Province in 2010 and 2011

(o C)

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	2010	33.2	35.3	36.1	37.1	36.6	34.6	33.4	32.3	32.1	30.5	30.6	31.1
	2011	30.8	33.6	32.5	33.8	34.0	33.4	33.5					
Min	2010	22.4	24.9	25.2	26.0	27.2	26.3	25.6	25.4	25.5	24.5	23.7	21.7
	2011	20.1	23.2	23.3	25.3	25.8	26.0	25.6					

Source: Department of Water Resources and Meteorology, BB Province *Station: Veal Bek Chan*

2.2 Socio-Economic Profile

Table 2.2-1 summarizes the socio-economic data of the Survey Area, focusing the 4 provinces substantially influenced by the Project.

Table 2.2-1 Socio-Economic Data of Survey Area (4 provinces only)

	Kampong Chhnang	Pursat	Battambang	Banteay Meanchey	Whole Country	Proportion to Whole Country (%)
Population	472,000	397,000	1,025,000	678,000	13,389,000	28.3
Land Area (ha)	552,100	1,269,200	1,170,200	6,67,900	18,103,500	20.2
Rice Field Area (ha)	127,700	95,300	234,100	210,800	2,566,800	17.8
Proportion of Rice Field Area (%)	23.1	7.5	20.0	31.6	14.2	N.A.
Rice Production (ton)	311,500	239,700	567,200	447,200	6,727,100	23.3

Source: Statistical Yearbook of Cambodia 2008

It is noted that the percentage of total population of the 4 provinces against that of the whole country is approximately 28% while the percentage of land area is only 20%. This means that the population density of the Survey area is higher than the national average, implying that the Survey Area is the developed area in Cambodia.

As can be seen in the above table, one of the most important industries in the Survey Area is rice production. Figure 2.2-1 shows the status of rice production of the provinces. In this figure, the provinces which supply rice other provinces are indicated in blue and light blue. In Figure 2.2-1, it is seen that the provinces in the Survey Area are major areas of rice production. This leads to traffic demand for transportation of rice via NR 5.

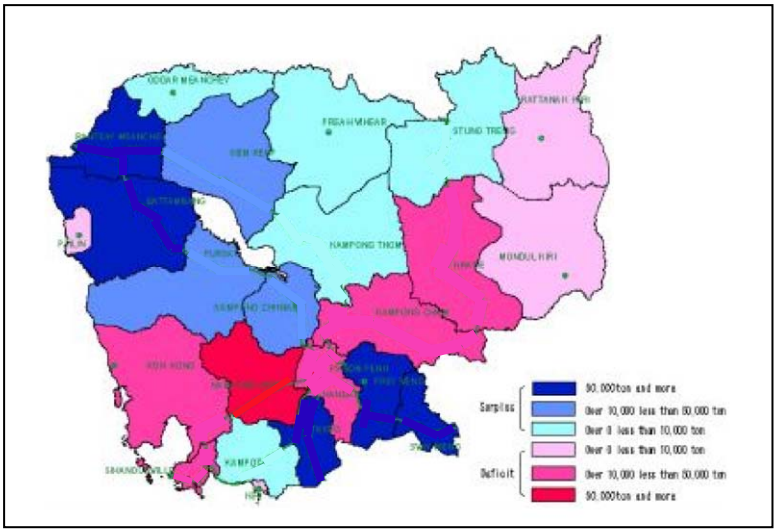


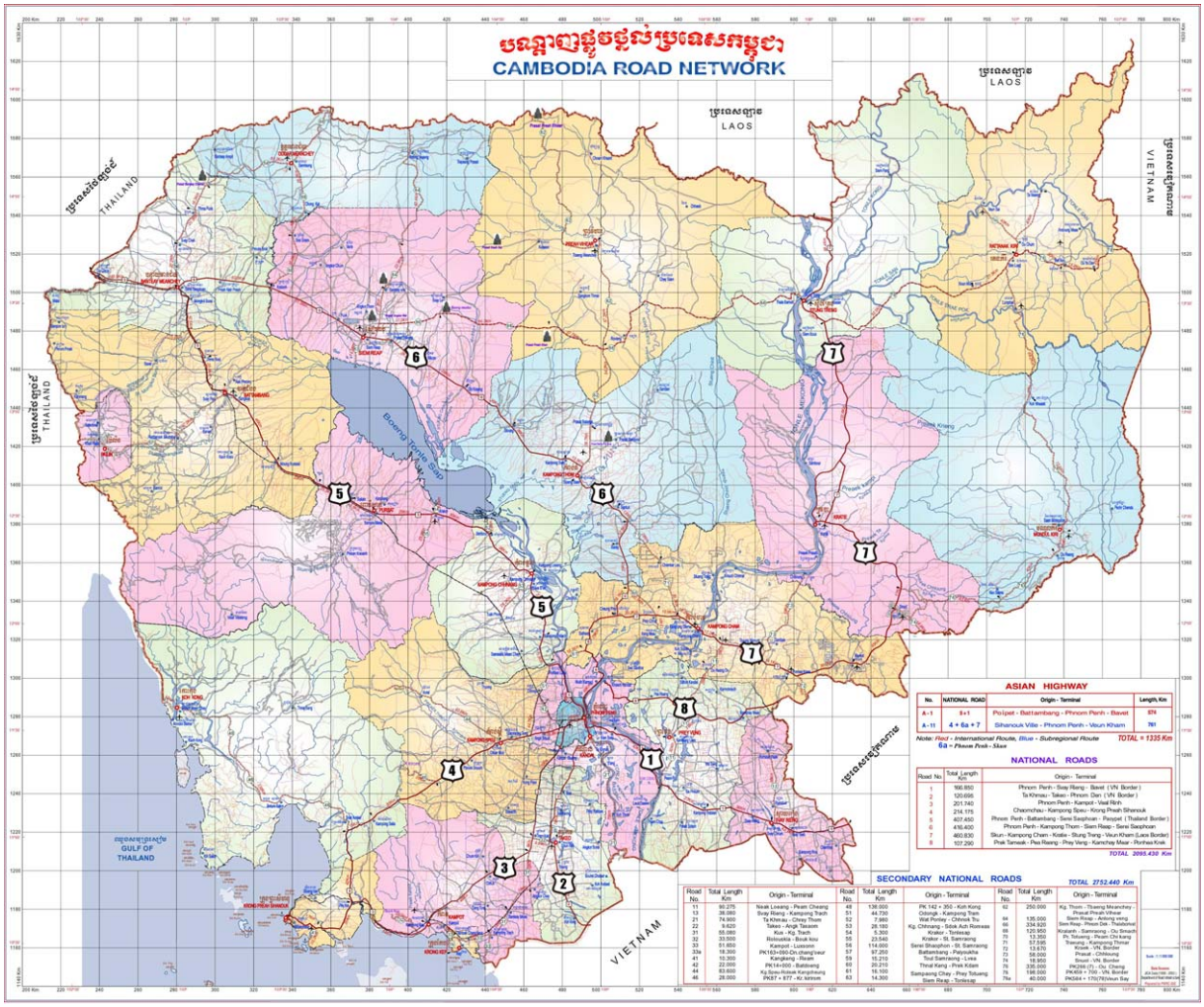
Figure 2.2-1 Rice Production by Province
(Quoted from the final report of 'the Study on the Road Network Development in the Kingdom of Cambodia, October 2006, JICA)

CHAPTER 3 NATIONAL ROAD NETWORK OF CAMBODIA AND ROLE OF NATIONAL ROAD NO. 5

3.1 National Road Network of Cambodia

3.1.1 National Road Network of Cambodia

National Road Network of Cambodia consists of arterial national roads with single digit numbers (1 to 8) with a total length of 2,096km and minor arterial roads with double digit numbers with a total length of 4,848km (as of end of year 2008). Figure 3.1-1 show the map of National Road Network of Cambodia. As can be seen in the figure, most of the arterial national roads of Cambodia is extend in radial directions centered at Phnom Penh and reach to the border points with neighboring countries of Vietnam and Thailand. They are numbered, in principle, in crock-wise direction starting from No. 1.



Source: MPWT

Figure 3.1-1 National Road Network of Cambodia

Table 3.1-1 shows the lengths and routes of arterial (single-digit) national roads.

Table 3.1-1 Length and route of Arterial National Road (As of 2008)

Road No.	Length (km)	Route
1	166.9	Phnom Penh – Bavet (Vietnam border)
2	120.7	Ta Kmau – Takeo – Phnom Den (Vietnam border)
3	201.7	Phnom Penh – Kampot – Veal Rinh
4	214.2	Chaom Chau – Kampong Speu – Krong Prea Sihanouk
5	407.5	Phnom Penh – Battambang – Sri Sophorn – Poipet (Thailand border)
6	416.4	Phnom Penh – Kampong Thom – Siem Reap – Sri Sophorn
7	460.8	Skun – Kamopong Cham – Kratie – Steung Treng – Veum Kham (Vietnam border)
8	107.3	Prek Kdam – Pea Reang – Prey Veng – Kamchay Mear – Ponhhea Krek

3.1.2 Surface Condition of National Road Network

Road network of Cambodia had deteriorated during the period of the civil war which ended in 1992 with signing of peace accord. Many bridges were collapsed and pavements were severely damaged. In 1990s, there were many impassable sections even on arterial national roads. Thus, road rehabilitation in 1990s and early 2000s mainly focused on urgent rehabilitation of arterial roads.

By late 2000s, most of urgent rehabilitation of the arterial roads had been completed. Most arterial national roads were passable and road surfaces were paved with mostly DBST. Further, some sections of arterial roads were paved with asphalt concrete as shown in Figure 1.1-1. By late 2000s, the focus for improving pavement condition had shifted from arterial national roads (single-digit roads) to minor arterial roads (double-digit roads).

However, the pavements of most sections of arterial roads are DBST which does not have sufficient bearing capacity to cater for heavy vehicles. The volume of heavy traffic is rapidly increasing on many roads due to rapid economic growth of Cambodia. This increase in heavy traffic is accelerating deterioration of DBST pavements and imposing heavy financial burden of maintenance to the Government of Cambodia.

Another problem of the existing national road network is insufficient road width or number of lanes. Road widths of most section are 2 lanes. Widths of some sections are even not sufficient for 2 lanes. This situation is resulting in deterioration in traffic safety condition and possible traffic congestions in the near future when traffic volume will increase.

3.1.3 Development Plan

National Strategic Development Plan (NSDP) 2006 – 2010 adopted 'Rectangular Strategy' as the very basic strategy/policy for national development. 'Further Rehabilitation of Physical Infrastructure' was designated as one of the four components of 'Rectangular Strategy'. The NSDP was updated in 2008 and issued as 'NSDP Update 2009 – 2013', which is currently valid. NSDP Update 2009 – 2013 prescribes 'Further Rehabilitation and Construction of Transport Infrastructure' as one of the four sub-components of 'Further Rehabilitation of Physical Infrastructure'. Then, NSDP Update 2009 – 2013 states 'Continuing to seek funding for ……(omitted)… the widening of NR 1, NR 4, **NR 5** and NR 6'.

Road network development in Cambodia is planned and implemented basically based on the master plan proposed by 'the Study on the Road Network Development in the Kingdom of Cambodia' conducted in 2006 by JICA (M/P Study). In this M/P Study, NR 5 was proposed to be improved to support 'Multi Growth Pole Development' and 'Development of International Corridor'. However, M/P Study proposed widening of NR 5 to 4 lanes between Phnom Penh and Kampong Chhnang and remaining sections were proposed to be 2 lanes.

The M/P Study was updated in 2009 in view of rapid economic growth and increase in vehicle registration in Cambodia, as well as several road improvement project implemented up to date. This update study reiterated the importance of NR 5 but no major change in widening to 4 lanes was proposed.

3.2 Role of National Road No. 5

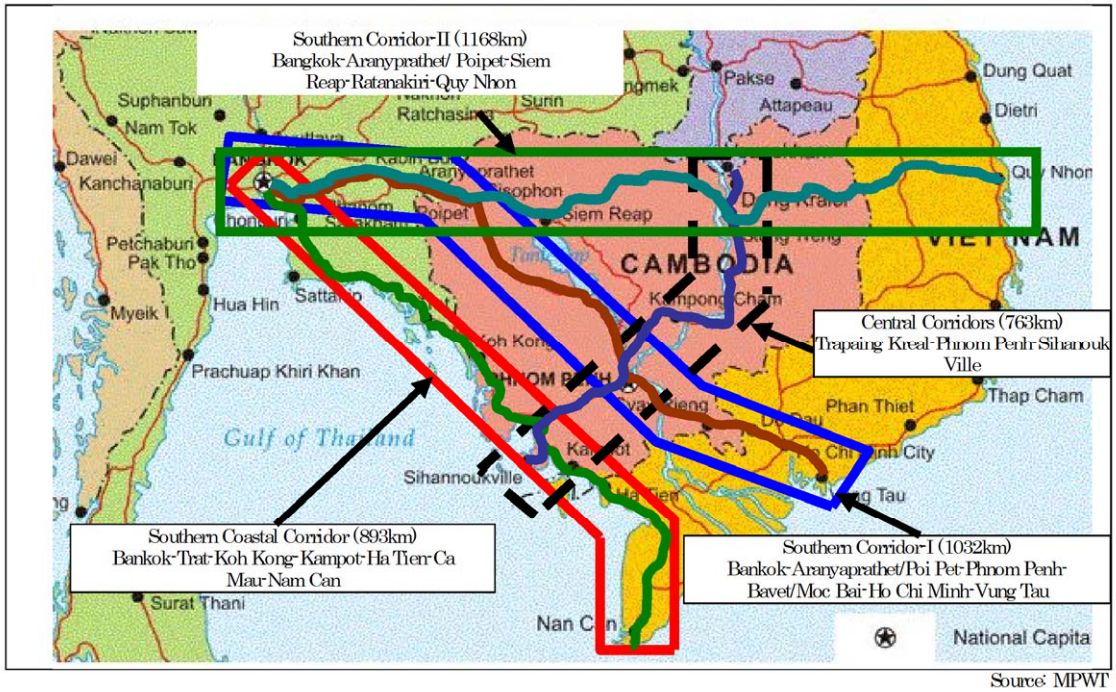
NR 5 is an arterial national road connecting Phnom Penh and Poipet, the border point with Thailand. It traverses provinces of Banteay Meanchey and Battambang whose populations are 3rd and 4th largest in the country. Thus, NR 5 accommodates the traffic needed for the day-to-day activities of the citizens, including access to the public services such as hospital and school, along the highway.

NR 5 also accommodates the traffic transporting goods and passengers between the major cities along the highway, such as Sri Sophorn, Battambang, Pursat, Kampong Chhinang and Phnom Penh. Further it is connected, via Phnom Penh, to National Road No. 1 (NR 1) which reaches to Ho Chi Min City in Vietnam and National Road No. 3 (NR 3) and National Road No. 4 (NR 4) which reach to Sihanoukville, the largest international seaport of Cambodia.

NR 5 is an important highway not only for domestic transport in Cambodia but also for international transport in ASEAN and the Greater Mekong Subregion (GMS). NR 5, together with National Road No. 1 (NR 1), forms a route connecting Bangkok, Phnom Penh and Ho Chi Minh City. Thus, NR 5 has been designated as ASEAN Highway No. 1 and Asian Highway No. 1. With rapid growth in the regional cooperation in GMS in the recent years, the importance of NR 5 is also rapidly growing.

Source: ASEAN Economic Community

Figure 3.2-1 ASEAN Highway



Source: Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia, Infrastructure and Regional Integration Technical Working Group, 2010

Figure 3.2-2 Economic Corridors of GMS

Importance of NR 5 as an international transport corridor has been recently increasing due to the development of regional cooperation in GMS, as seen in the signing and ratification of Cross-Border Transport Agreement (CBTA) in 2008:

Cross-Border Transport Agreement

Cross-Border Transport Agreement (CBTA) is a compact and comprehensive multilateral instrument that covers all the relevant aspects of cross-border facilitation including the followings:

- *Facilitation of border crossing formalities (single-window and single-stop custom inspection, coordinating of hours of operation, and exchange of advanced information and clearance)*
- *Facilitate cross-border movement of people (multi-entry visa, recognition of driver license)*
- *Facilitate cross-border movement of goods (regional transit regime)*
- *Exchange of commercial traffic rights*
- *Requirements for admittance of road vehicles*
- *Institutional arrangements*
- *Setting-up custom transits (guaranteeing system)*
- *Coordination on bridge design standards, road signs and signals*

The CBTA is expected to accelerate the regional cooperation in GMS and further increase the importance of NR 5.

CHAPTER 4 PRESENT CONDITION OF NATIONAL ROAD NO. 5

4.1 Physical Condition of National Road No. 5

4.1.1 Overall Conditions

Figure 4.1-1 (a) through (c) show the overall physical conditions of NR 5 in the form of 'straight line diagram'. This diagram has been prepared based on the information obtained through the site survey conducted from late February to late March 2011.

MPWT is currently installing kilometer posts (KP) along NR 5. The straight line diagram shown in Figure 4.1-1 basically uses this KP. In this diagram, the whole Survey Section of NR 5 is divided into 3 sections; South Section (KP 32 – KP 171), Middle Section (KP 171 – KP 301) and North Section (KP 301 – KP 361).

The criteria for classification of the conditions shown in the diagram are as described below:

Table 4.1-1 Description of Classification for Straight Line Diagram

Item	Classification	Description
Inundation	Overflow	Overflow on the road surface
	Near by	Water level rose to near but lower than road surface
	None	No report of inundation
Drainage	Bad	Water logs remain on the road after rain
	Poor	Water logs are seen at roadside after rain
	Fine	No remaining water on the road or roadside after rain
Pavement	Bad	Function of pavement substantially lost due to occurrence of several types of defects
	Poor	Function of pavement lost to light degree due to occurrence of a few types of defects
	Fair	No major defects observed
Project Affected Persons (PAPs)	Many	Buildings densely located along the roadside
	Few	Buildings sparsely located along the roadside
	None	No building nearby the road
Resettlement	Many	Roadside heavily populated
	Few	Houses sparsely located close to the road
	None	No houses nearby the road

The following subsections describe the conditions of each item.

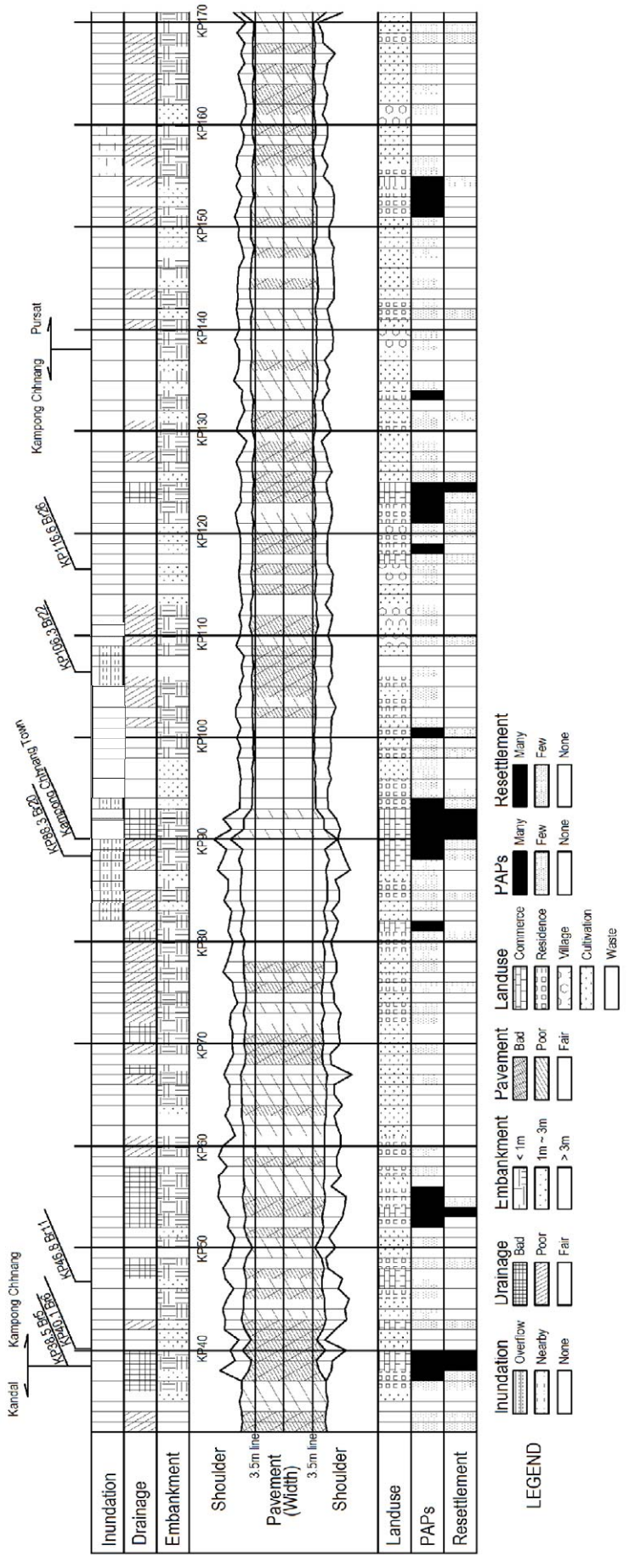


Figure 4.1-1 (a) Straight Line Diagram : South Section (KP 32~KP 171)

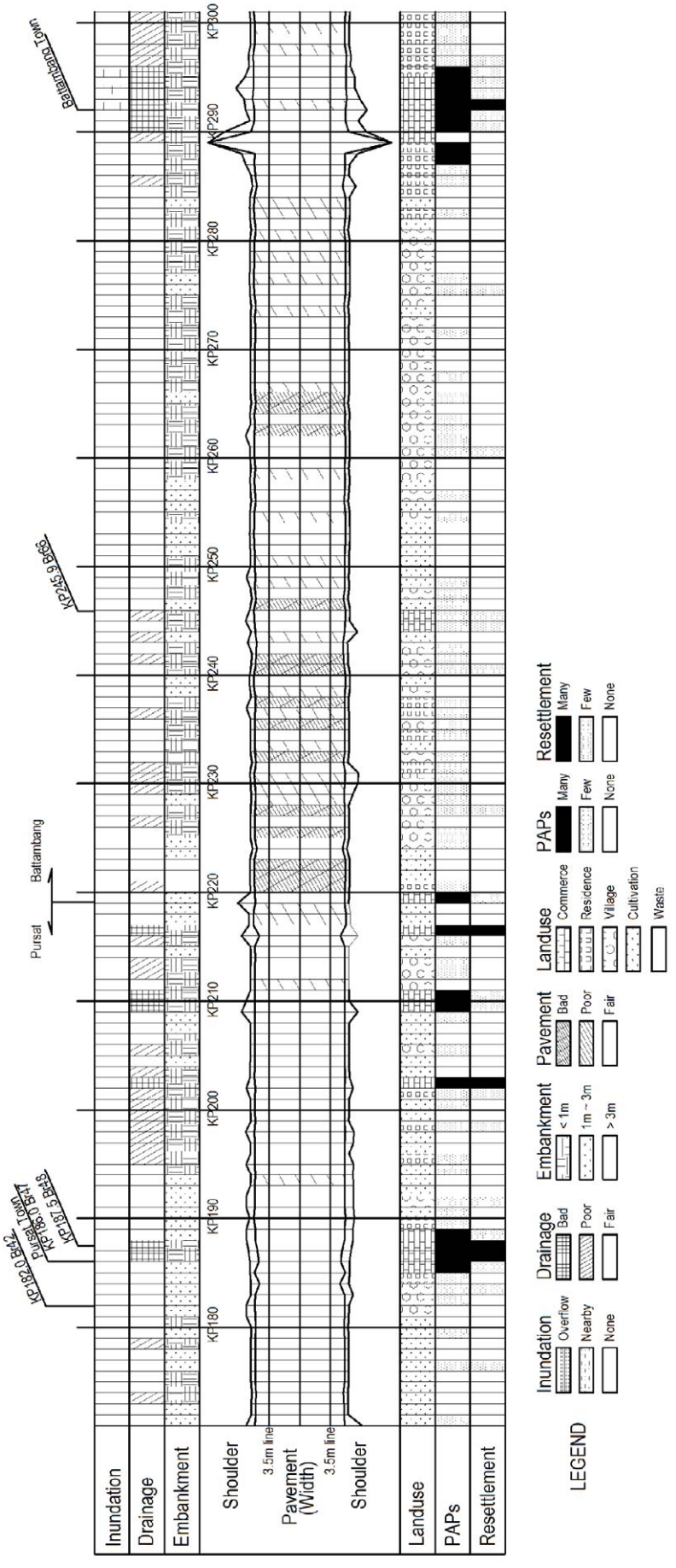


Figure 4.1-1 (b) Straight Line Diagram : Middle Section (KP 171~KP 301)

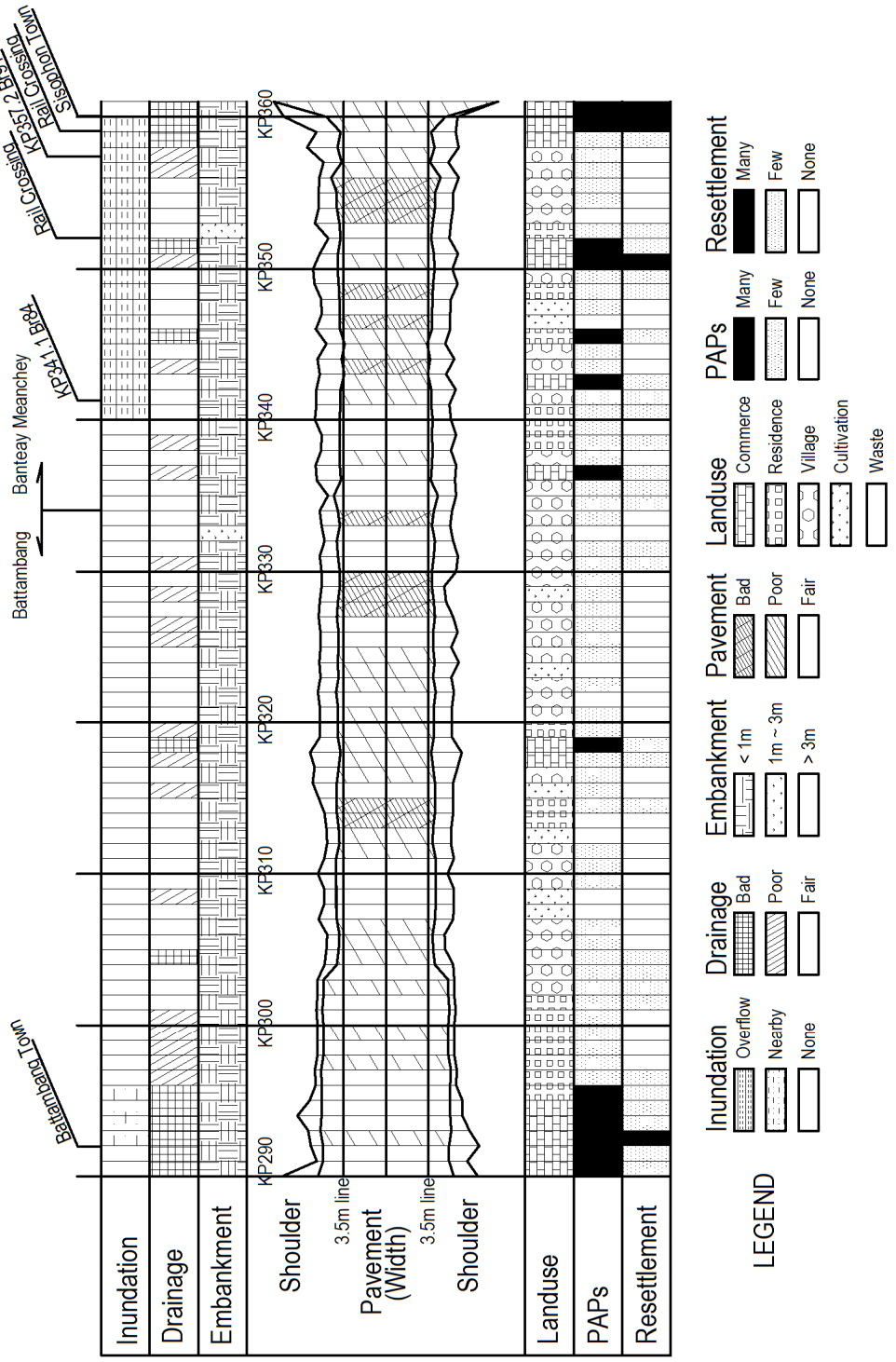


Figure 4.1-1 (c) Straight Line Diagram : North Section (KP 301~KP 361)

4.1.2 Geometric Structure

(1) Horizontal Alignment

Horizontal alignment of NR 5 is generally generous. Where there is a curve, the radius is usually large enough to satisfy the criteria of geometric design of Cambodia. Some sharp curves are found near the major cities such as Oudong, Kamopong Chhnang, Battambang and Sri Sophorn. Improvement of these sharp curves are discussed in Subsection 10.2.3: Horizontal Alignment of Chapter 10.

(2) Vertical Alignment

As NR 5 generally traverses flat terrain, its vertical alignment is also generally flat. Some sections with steep grade are found particularly near the bridges. Whether or not these steep-grade sections satisfy the design criteria will be discussed also in the 2nd Stage of the Survey.

The height of road embankment is another important subject in view of the flood. The table below shows the summary of embankment height. The problem of flood is discussed in Chapter 7.

Table 4.1-2 Embankment Height

Section	Embankment Height	Inundation
South Section	-0.3 ~ 5.0m	Some sections in 2002&04
Middle Section	-0.3 ~ 2.5m	Inside town by heavy rain
North Section	0.0 ~ 2.5m	Few sections in 2010

* Minus (-) embankment height indicates that the height of the road surface is lower than the ground surface adjacent to the road.

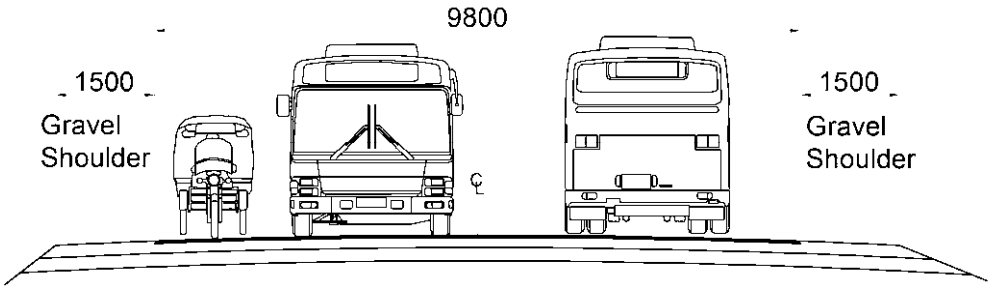
(3) Cross-Sectional Composition

Cross section of NR 5 is composed of 2-lane carriageway and shoulders except few hundreds meter long stretches in Battambang and Sri Sophorn. The improved section between Sri Sophorn and Poipet, the border point with Thailand, also has the same cross-sectional composition. The photo shown at right was taken between Prek Kdam Br. ~ Kampong Chhnang.

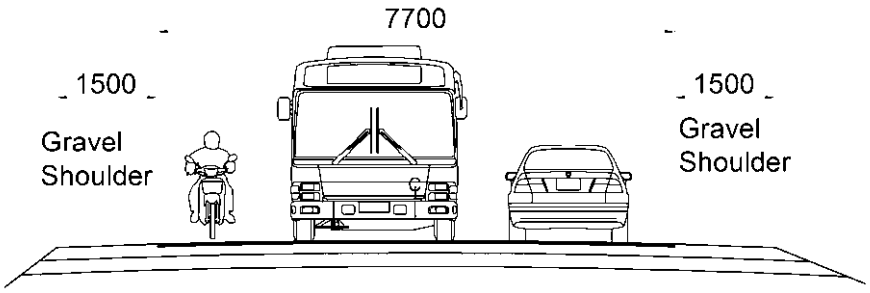
Photo 4.1-1 Edge Line and Paved Shoulder

South Section

There are two types of typical cross section on the South Section. The average width of pavement is 9.8m between Prek Kdam Bridge and Kampong Chhnang, and is 7.7m between Kampong Chhnang and Thlea Ma'Am. The wider section has enough space to separate motorcycles and carts from 4-wheel vehicles, while the narrow section does not have any separate space for motorcycles. The typical cross sections of the South Section are shown in Figure 4.1-2.



Prek Kdam Br ~ Kampong Chhnang

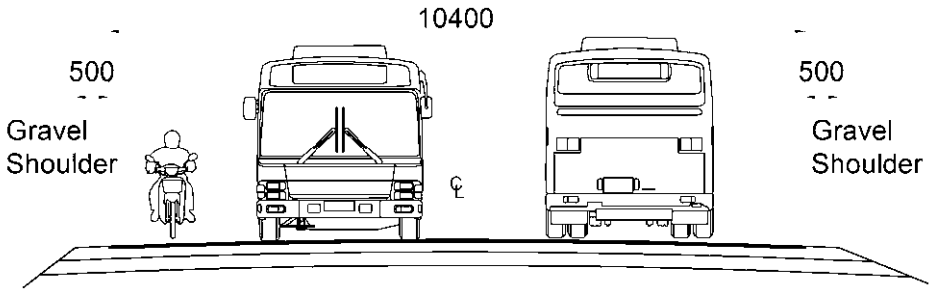


Kampong Chhnang ~ Thlea ma'Am

Figure 4.1-2 Typical Cross Section of South Section

Middle Section

The average width of pavement on middle section is the widest in NR 5 except for few hundreds meter portions of 4-lane near Battembang city. The shoulder is paved by SBST and it provides enough space for motorcycles and carts. The additional shoulders with gravel have been constructed for the protection of edge damage. The typical cross section of the Middle Section is shown in Figure 4.1-3.

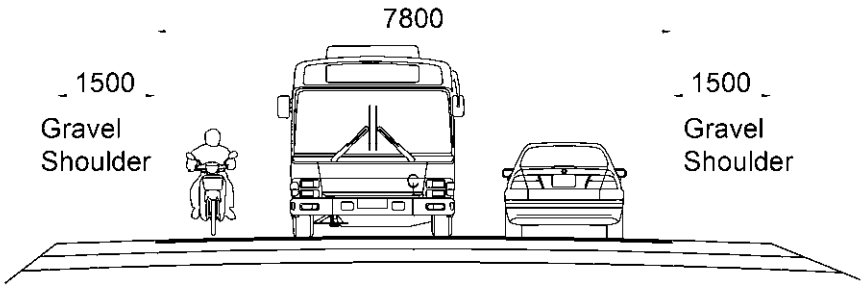


Thlea ma'Am ~ Battambang

Figure 4.1-3 Typical Cross Section of Middle Section

North Section

The average width of pavement on north section is 7.8m. The cross-sectional composition is similar with the section between Kampong Chhnang and Thlea Ma'Am. The vehicles overtaking slow traffic use the opposite lane due to insufficient space in the traveling lane. The typical cross section of north section is shown in Figure 4.1-4.



Battambang ~ Sri Sophorn

Figure 4.1-4 Typical Cross Section of North Section

Sri Sophorn-Poipet Section

The cross section beyond Sri Sophorn is similar with that of the Middle Section, but the pavement type is asphalt concrete. This section is directly connecting to the border with Thailand and has recently been improved. Therefore, this cross section composition can be a good reference case for this project. The general cross section of the section between Sri Sophorn and Poipet is shown in Figure 4.1-5.

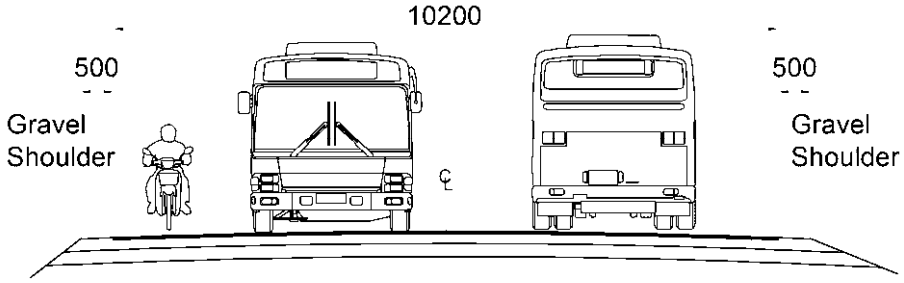


Figure 4.1-5 General Cross Section of Sri Sophorn-Poipet Section

(4) Summary of Problems

The major problems of geometric structure known at this stage are the following two:

- The narrow pavement width
- The insufficient height of embankment

4.1.3 Pavement Condition

The condition of existing pavement was closely observed at the points of failure and every 1km interval where fixed kilometer post exists.

The maintenance of the pavement has been carried out well in general. Completed repair works such as patching, overlay and seal coat are observed. The maintenance works under RAMP also have been carried out in the section from KP 3.9 to KP 171 of NR 5. Several kinds of failure have been thoroughly repaired in RAMP.

The typical failures of the pavement observed on NR 5 are as described below:

- Crack: There are two types of crack; longitudinal line crack on the shoulder and mesh crack on the depressed area. The longitudinal line cracks are supposed to be caused by the settlement of embanked ground
- Pothole: Most of the large potholes have been repaired, but there are some small holes not reaching base course layer without being addressed. These small halls usually further develop during rainy season.
- Depression: Usually observed in the right wheel tracks of vehicles due to insufficient strength of the pavement and/or penetration of water into the pavement structure.
- Flush (Bleeding): Seeping out of bituminous material to the pavement surface. Cased by excess use of bitumen.
- Rutting: Observed on the wheel tracks of vehicles; caused by insufficient strength of the pavement compared to the traffic load.
- Aggregate loss: Breakaway of surface aggregate is observed on the old surface due to the poor adhesion of deteriorated bitumen or insufficient binder.
- Edge Damage: Wear of shoulder caused by action of water and/or vehicle entering to the road.
- Shoving: Usually it is observed near the edge of the pavement due to the ingress of water reducing the bearing capacity of the pavement and/or subgrade.

The locations where these defects are observed are summarized below:

South Section (KP 32~KP 171)

Failure	Location
Crack	KP 32 ~ KP 54, KP 136 ~ KP 167
Depression	KP 32 ~ KP 77, KP 102 ~ KP 170
Aggregate Loss	KP 93 ~ KP 98
Edge Damage	KP 92 ~ KP 131

Middle Section (KP 171~KP 301)

Failure	Location
Crack	KP 232 ~ KP 248, KP 259 ~ KP 284
Depression	KP 217 ~ KP 243, KP 262 ~ KP 266
Rutting	KP 187 ~ KP 268
Edge Damage	KP 216 ~ KP 220

[Note] The surface condition is comparatively fair in the Middle Section and the original surface course constructed under PRRP is still being used without major repair in general. It seems that the bearing capacity of the pavement is stronger than the other two sections.

North Section

Failure	Location
Crack	KP 311 ~ KP 322, KP 338 ~ KP 357
Depression	KP 302 ~ KP 306, KP 311 ~ KP 324, KP 341 ~ KP 348, KP 353 ~ KP 360
Rutting	KP 325 ~ KP 335, KP 347 ~ KP 355
Aggregate Loss	KP 350 ~ KP 351, KP 360 ~ KP 361

[Note] Percentage of commercial and residential usage of roadside land along this section is higher than the other two sections. The elevation of road surface is sometimes lower than the roadside land. This makes weakening of the pavement due to the penetration of rain water into the roadbed.

Photo 4.1-2 Roadside Higher than Road Surface without Drainage

4.1.4 Bridge Condition

The number of bridges located on the Survey Section is 87 in total. Some of the bridges are constructed by the fund of Australia in the middle of 1990s and their structures with steel plate girders are still stable. Most of the bridges are constructed under PRRP and EFRP after the extensive flood in 2000. The superstructure of those bridges is prestressed concrete (PC) hollow slab and its condition is quite good. The other bridges are also still in fair condition for supporting the present traffic load. Only one bridge located in Kampong Chhnang City (bridge code Br 20 at KP 88) is seriously damaged. The bottom of reinforced concrete (RC) slab is

exfoliated and rusted steel bars are exposed. Thus this bridge needs to be replaced urgently to provide the safe road service.

Even though the present condition is still fair, the reconstruction of old bridges and culverts will be required when the road will be widened. Also safety of old bridges against the increased traffic load is not certain. Therefore the basic policy of bridge works should be replacement of old bridges. The old bridges to be replaced are listed up in Table 4.1-3.

Photo 4.1-3 Damage of Br20

Table 4.1-3 Bridges Considered to be Replaced

KP	Code	Length	Carriageway Width	Bridge Type
South Section				
38.5	Br 5	9.15 m	10.75 m	2 span Rigid Frame RC Girder
40.1	Br 6	24.0 m	8.1 m	2 span Simple Steel Plate Girder
46.8	Br 11	16.7 m	10.4 m	4 span Rigid Frame RC Slab
88.3	Br 20	6.0 m	13.6 m	1 span RC Slab
106.3	Br 22	91.0 m	7.3 m	4 span Simple Steel Plate Girder
116.6	Br 26	71.0 m	7.25m	3 span Simple Steel Plate Girder
Middle Section				
182.0	Br 42	19.4 m	9.7 m	4 span Simple RC Girder
186.0	Br 47	120.0 m	7.3 m	6 span Simple PC Girder
187.5	Br 48	38.9 m	8.8 m	2 span Simple RC Girder
245.9	Br 66	9.7 m	9.3 m	2 span Simple RC Girder
North Section				
341.1	Br 84	4.9 m	10.2 m	2 span Rigid Frame RC Arch
357.2	Br 91	14.4 m	8.6 m	3 span Simple RC Girder

Regarding two bridges in the South Section (bridge code Br 22 at KP 106.3 and Br 26 at KP 116.6) the pier is constructed on pile-bent type, and some of the foundation piles are battered piles. This implies that the construction of additional piles for expansion bridge seat is difficult. Thus, replacement is needed if these bridges are to be widened.

Photo 4.1-4 Battered Piles of Br 26

4.1.5 Roadside Land Use

The cities, towns and villages are developed along the road. Many factories, shops, stalls, vendors, benches and houses are observed just beside the road. The basic form of land use outside of urbanized area is agriculture, especially rice paddy. There are many rice mill factories and warehouses along the road functioning as the base station of transportations for rice.

Negligence of Drainage

The roadside of existing route has been developed rapidly such as new factories, commercial activities and residential buildings. Land fill for such development after pay very little attention to the necessity of drain channel at road shoulder. Some houses and shops bury the existing drainage channel of their front for their convenience of access. As a result, rain water stays on the road surface or penetrates through the road bed and subgrade soil causing damage to the pavement.

Occupancy of ROW by Roadside Shops and Utilities

In town areas, private shops occupy the existing road shoulder and sidewalk to display their merchandise, and their buildings are placed within Right of Way. On the other land, most of the houses are built outside of Right of Way and some houses are moving to their backyard by their intention. It may be the effect of the notice board installed by ADB project to announcing the width of Right of Way of 30 m from the center of existing road. The boards are installed on roadside at many locations on the whole stretch of NR 5.

Announcement about National Corridor

Decree about the corridor management along national roads and rail of the Kingdom of Cambodia No. 197 issued on the 23rd of November 2009 article No. 8 states that the corridor is limited for development process on the infrastructure as below:

National Road Level 1: Represent as 1 digit number, the corridor has 30 meter width from the center of the road axe so all the constructions must follow to this decree by keep the space at lease 30 meter from the center of road axe. Moreover, for the public service equipment such as Electric poles, Telephone line Poles, Optical Cables etc… must be placed at lease 28 meter from the central road axe.

(as shown in figure below)

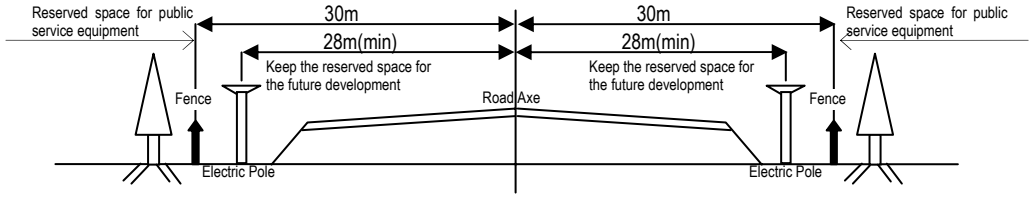


Figure 4.1-6 Notice Board of Right of Way (Unofficial Translation)

Although, it is instructed on the board that electric poles should be installed 28 m away from the road center, actual installation work of new electric poles is ongoing approximately 17 m away from the road center. This will bring confusion among the residents. It is strongly recommend that MPWT shall issue the warning to SKL Group, who has been installing electric poles within the road reserves.

4.2 Planned, Ongoing and Past Project for Rehabilitation/Improvement of NR 5

This subsection summarized the past projects which contributed to the current condition of NR 5, as well as the on-going and planned project which are expected to improve the current condition of NR 5.

(a) ADB: Primary Roads Restoration Project (PRRP)

The whole stretch of NR 5 had been originally scheduled to be improved in the ADB funded "Primary Roads Restoration Project (PRRP). Due to the severe flood occurred on 2000, some parts of NR 5 covered by the contract packages of PRRP were damaged, and extensive rebuilding and improvements became necessary (e.g., repair of eroded embankments, raising of embankment heights, construction of additional culverts, bridge rehabilitation etc.). As a result, 130 km of the Middle Section was improved under contract packages of PRRP.

(b) ADB: Emergency Flood Rehabilitation Project (EFRP)

Two cancelled package of PRRP were transferred to the subprojects of "Emergency Flood Rehabilitation Project (EFRP) funded by ADB. This project was aimed to restore damaged facilities to their pre-flood conditions to permit early restoration of economic and social activities. Given the Project's urgent nature, the detailed design was left for implementation and the rehabilitation works were commenced immediately with ensuring dry season. The design process depends heavily on national ministries and provincial agencies for information on the extent of damage. Therefore 139 km of the South Section and 60 km of the North Section except bridge works, reconstruction of bridges covered by PRRP Package 5E, were restored under contract packages of EFRP.

(c) ADB: Cambodia Road Improvement Project (CRIP)

The contract package 5F or PRRP, the section between Sri Sophorn and Poipet, was implemented under Cambodia Road Improvement Project (CRIP) funded by ADB. The road was paved with AC and the cross section composition is 2-lane road with motorcycle lane. Total width of the pavement is 10.2 m.

(d) Project Funded by Phnom Penh Municipality and Chinese Government

Regarding the section between Phnom Penh and Prek Kdam Bridge which is outside of scope of this Survey, a short stretch of approximately 8 km was overlaid with asphalt concrete (AC) recently by the fund of Phnom Penh Municipality, and there is a plan to upgrade into 4-lane with AC pavement over the whole section by Chinese fund on the period from 2012 to 2015. If this plan will come to reality, the section from Phnom Penh to the South Section will be greatly improved in the near future.

(e) ADB: Road Asset Management Project (RAMP)

Road Asset Management Project (RAMP) funded by ADB implements the maintenance work between Phnom Penh (KP 3.9) and Thlea Ma'Am (KP 170.9) in 2010 and 2011. The contents of the work are the installation of road signs, guide posts, lane marking and kilometer posts and the repair of cracks, potholes, depression, rutting, shoving, corrugation, base course failure, edge break damage and full depth reconstruction of failure. Any improvement or upgrading works are not carried out in this project.

The recent projects on NR 5 are listed in Table 4.2-1. The locations of repair/rehabilitation works executed under these projects are schematically illustrated in Figure 4.2-1.

Table 4.2-1 Project List on National Road No. 5

Section	Project	Year
Phnom Penh ~ Prek Kdam Br.	Restored by Army RAMP funded by ADB 4-lane widening by China fund	2000 - 2002 2010 - 2011 2012 -
Prek Kdam Br. ~ Kampong Chhnang (South Section)	Restored by Army RAMP funded by ADB	2000 - 2002 2010 - 2011
Kampong Chhnang ~ Thlea Ma'Am (South Section)	EFRP funded by ADB RAMP funded by ADB	2000 - 2004 2011 - 2012
Thlea Ma'Am ~ Battambang (Middle Section)	PRRP funded by ADB	2000 - 2005
Battambang ~ Sri Sophorn (North Section)	EFRP funded by ADB	2000 - 2004
Sri Sophorn ~ Poipet	CRIP funded by ADB	2004 - 2007

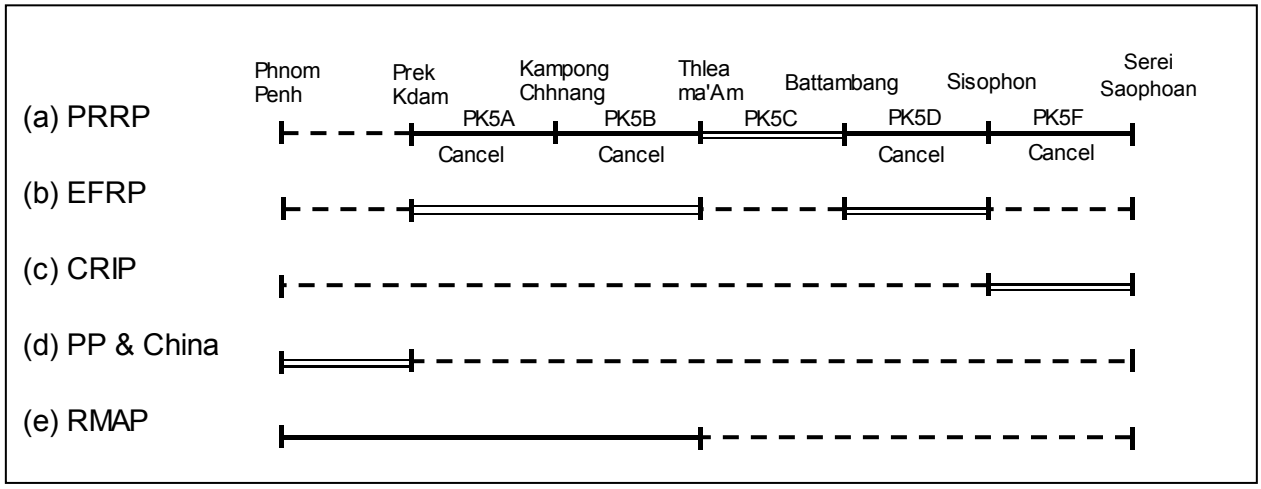


Figure 4.2-1 Schematic Illustration of Location of Works Executed under Projects Cited Above

CHAPTER 5 TRAFFIC SURVEYS

Traffic surveys were carried out on the National Road No. 5. The objectives of the surveys were to have better understanding on the characteristic of the Survey Area, as well as the present traffic pattern. The data obtained through the traffic surveys are also used in forecasting future traffic demand, which, in turn, is used in evaluation of priority of the South, Middle and North Sections and planning of cross sections.

The following three (3) types of the survey were conducted, namely; traffic count survey (12hr and 24hr), origin destination (OD) interview survey and travel speed survey. The outline, method and result of the survey are explained in each section below.

5.1 Traffic Count Survey

5.1.1 Outline

The traffic counts were conducted at eight (8) stations with three (3) vehicle groups and eight (8) vehicle classifications. 24 hours counts were carried out at two (3) stations from 6:00 a.m. to 6:00 a.m. next day and 12 hours counts at six (6) stations from 6:00 a.m. to 6:00 p.m. These traffic counts were carried out on weekdays, excluding Saturday, Sunday and national holidays. The groups and classifications of vehicle were classified as follows.

Table 5.1-1 Vehicle Classification for the Traffic Count Survey

Group		Classification	
I	Motor Cycle (MC)	1	Motorcycle and Motor Tricycle
		2	Motorbike Trailer
II	Light Vehicle (LV)	3	Sedan, Wagon, Light Van and Pick-up(for passenger)
		4	Pick-up(for commodity), Jeep and Light Truck (>3.5t)
		5	Mini Bus (Van type and Pick-up Type)
III	Heavy Vehicle (HV)	6	Short and Long Body Bus
		7	Short and Long Body Truck (<3.5t)
		8	Semi and Full Trailer Truck

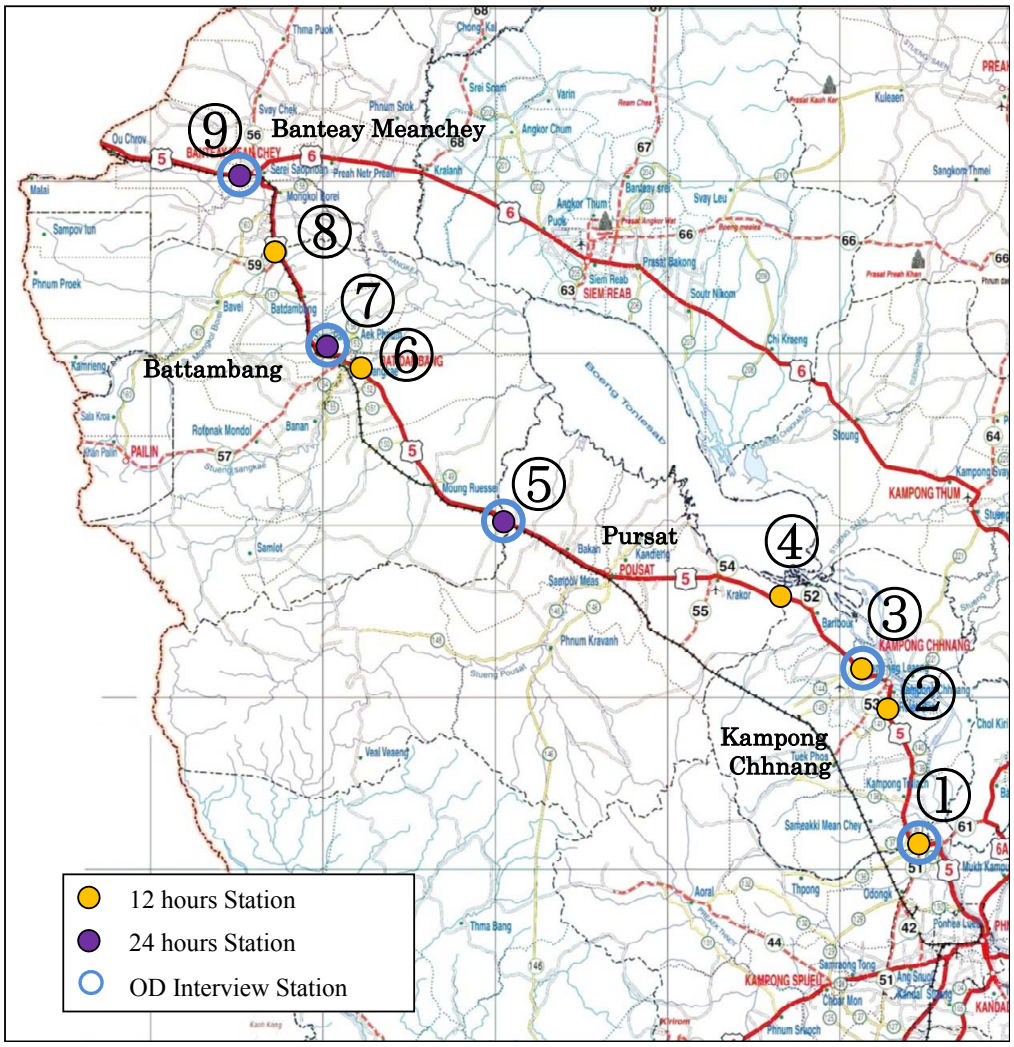
5.1.2 Location of Traffic Count Survey

The survey locations were selected at the provincial boundary and city boundary (Kompong Chhnang City and Battambang City) and they are shown in Table 5.1-2 and Figure 5.1-1, respectively.

Table 5.1-2 Location of Traffic Count Survey

No	Location	Time	Year 2011 and Date
1	Provincial Boundary (between Kadal and Kampong Chhnang)	12 hrs	22 March (Tue)
2	Kampong Chhnang City (Southern)	12 hrs	22 March (Tue)
3	Kampong Chhnang City (Northern)	12 hrs	22 March (Tue)
4	Provincial Boundary (between Kampong Chhnang and Pursat)	12 hrs	22 March (Tue)
5	Provincial Boundary (between Prusat and Battambang)	24 hrs	22-23 March (Tue and Wed)
6	Battambang City (Southern)	12 hrs	22 March (Tue)
7	Battambang City (Northern)	24 hrs	22-23 March (Tue and Wed)
8	Provincial Boundary (between Battambang and Banteay Meanchey)	12 hrs	22 March (Tue)
9	Sri Sophorn Suburb(Western)	24 hrs	23-24 November(Wed and Thrs)
Note: 24 hrs: from 06:00 in the morning to 06:00 in the following morning 12 hrs: from 06:00 in the morning to 18:00 in the evening			

Figure 5.1-1 Location of Traffic Count Survey



5.1.3 Survey Result

The results of the traffic count survey are as described below.

(1) 12-hour traffic volume and vehicle composition

Table 5.1-3 shows 12 hours traffic volume by vehicle group and classification. The traffic volume at station 6 and 7 (boundary of Battambang City) were over 10,000 vehicles.

Table 5.1-3 Traffic Volume for 12 Hours

Unit: Vehicle

Station No.	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)			Grand Total
	Motorcycle and Tricycle	Motorbike Trailer	Total	Sedan, Wagon and Light Van	Pick-up, Jeep and Light Truck	Mini Bus	Total	Short & Long Body Bus	Short & Long Body Truck	Total	
1	4,148	318	4,466	1,562	534	796	2,892	184	484	72	740
2	4,748	101	4,849	1,596	555	509	2,660	190	294	19	503
3	3,505	51	3,556	1,207	365	503	2,075	181	297	35	513
4	670	38	708	809	264	356	1,429	177	247	23	447
5	1,475	48	1,523	756	282	349	1,387	176	315	32	523
6	11,339	423	11,762	1,541	621	487	2,649	171	646	31	848
7	7,107	412	7,519	1,768	526	433	2,727	131	246	72	449
8	3,615	201	3,816	1,297	311	280	1,888	98	555	50	703
9	3,128	81	3,209	2,221	431	272	2,924	90	306	119	515

Figure 5.1-2 shows the vehicle composition at each survey station. Ratio of Motorcycle (MC) to total vehicle is more than 50% at most stations. The volume of MC is less than that of Light Vehicle (LV) at station No. 4 and No. 5. This may be attributed to the fact that there is no housing and facilities nearby.

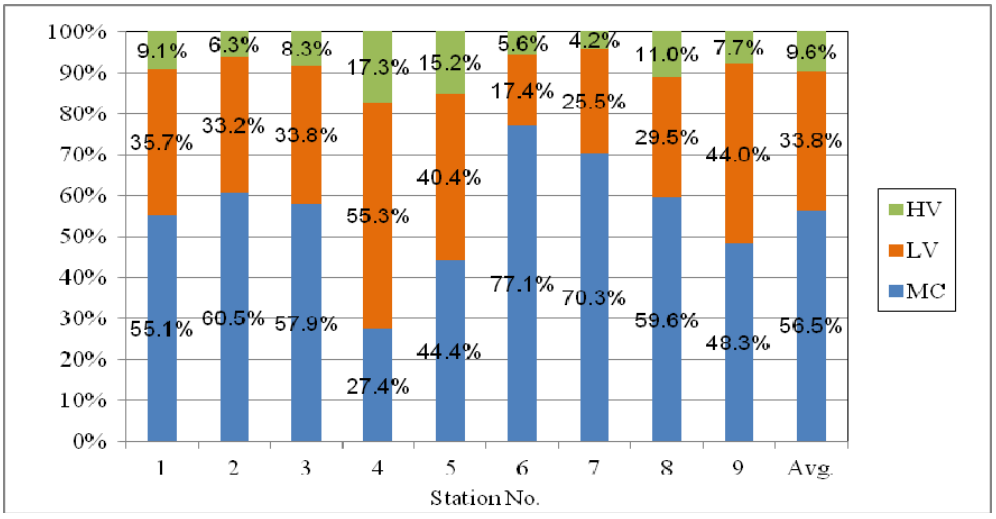


Figure 5.1-2 Vehicle Composition by Survey Station

(2) Peak hour traffic volume

Table 5.1-4 shows the peak hour traffic volume for all vehicles and for Heavy Vehicle (HV) in the two directions of "to Poipet" and "to Phnom Penh". There was no particular time zone of peak traffic common to all counting stations.

Table 5.1-4 Peak Hour Traffic Volume by Direction

Unit: Vehicle

Station No.	Traffic count hour	Direction			
		Phnom Penh ⇒ PoiPet		PoiPet ⇒ Phnom Penh	
		Maximum hourly traffic volume	Time zone	Maximum hourly traffic volume	Time zone
1	12	483	7:00-8:00	379	16:00-17:00
2	12	517	7:00-8:00	441	17:00-18:00
3	12	331	11:00-12:00	395	7:00-8:00
4	12	151	9:00-10:00	126	11:00-12:00
5	24	166	10:00-11:00	201	21:00-22:00
6	12	887	8:00-9:00	809	17:00-18:00
7	24	553	17:00-18:00	575	8:00-9:00
8	12	301	8:00-9:00	344	9:00-10:00
9	24	365	9:00-10:00	324	17:00-18:00

(3) 24 hour/12 hour ratio

The 24 hour traffic count was carried out at three (3) stations (No. 5, No. 7 and No. 9) in order to confirm the trend of the traffic volume in rural area and at boundary of the city on the National Road No. 5. The rations of 24 hour/12 hour by vehicle classification are shown in Table 5.1-5 and Table 5.1-6, respectively. The 24 hour/12 hour ratio of Semi & Full Trailer Truck is the highest among those of various vehicle types, and is more than two (2) times of others. This means the semi & full trailer trucks move actively during night rather than daytime. It is assumed that they intend to avoid traffic congestion at those places.

Table 5.1-5 24 Hours/12 Hours Ratio at Station 5 (Rural Area)

Unit: Vehicle

Area	Station No.	Motorcycle (MC)		Light Vehicle (LV)			Heavy Vehicle (HV)			Grand Total
		Motorcycle and Tricycle	Motorcycle Trailer	Sedan, Wagon and Light Van	Pick-up Jeep and Light Truck	Mini Bus	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	
Rural	12 hour	1475	48	756	282	349	176	315	32	3433
	24 hour	1674	50	970	357	391	195	567	194	4398
	24/12 ratio	113	1.04	1.28	1.27	1.12	1.11	1.80	6.06	1.28

Table 5.1-6 24 Hours/12 Hours Ratio at Station 7 (Boundary of City)

Unit: Vehicle

Area	Station No.	Motorcycle (MC)		Light Vehicle (LV)			Heavy Vehicle (HV)			Grand Total
		Motorcycle and Tricycle	Motorcycle Trailer	Sedan, Wagon and Light Van	Pick-up Jeep and Light Truck	Mini Bus	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	
Near the Enter City	12 hour	7107	412	1768	526	433	131	246	72	10695
	24 hour	8238	484	2205	651	516	157	382	193	12826
	24/12 ratio	1.16	1.17	1.25	1.24	1.19	1.20	1.55	2.68	1.20

(4) Conversion to 24 hours (daily) traffic volume

The 24 hours (daily) traffic volumes were calculated using the conversion factor of 24 hours/12 hours ratio of rural area and city boundary. The conversion factor for rural area is applied to traffic volume at station No.1, 4 and 8 and that for city boundary is applied to those at station No. 2 and 6 respectively. The results of 24 hours traffic volume are shown in Table 5.1-7.

Table 5.1-7 Daily (24 Hour) Traffic Volume

Unit: Vehicle

Station No.	Motorcycle			Light Vehicle				Heavy Vehicle			Grand Total
	Motorcycle and Tricycle	Motorcycle Trailer	Total	Sedan, Wagon and Light Van	Pick-up, Jeep and Light Truck	Mini Bus	Total	Short & Long Body Bus	Short & Long Body Truck	Total	
1	4708	331	5039	2004	676	892	3572	204	437	1512	10122
2	5504	119	5622	1990	687	607	3284	228	51	735	9641
3	4063	60	4123	1505	452	599	2556	217	94	772	7451
4	760	40	800	1038	334	399	1771	196	139	780	3351
5	1674	50	1724	970	357	391	1718	195	194	956	4398
6	13143	497	13640	1922	769	580	3271	205	83	1291	18202
7	8238	484	8722	2205	651	516	3372	157	193	732	12826
8	4103	209	4312	1664	394	314	2372	109	303	1411	8094
9	3476	92	3568	2816	545	312	3673	113	314	812	8053

5.2 Origin Destination (OD) Survey

5.2.1 Outline

Origin Destination (OD) survey was carried out to establish travel patterns (where people are moving to/from). ODs of vehicles were surveyed through roadside interviewed to the drivers. This method is most commonly practiced. Interviews to vehicle drivers were carried out in 12 hours from 6:00 a.m. to 18:00 pm on Tuesday 22nd of March and 23rd of November (Station 9) during the same time with the traffic count survey was conducted (See Table 5.1-2 and Figure

5.1-1). The target sample rate was set at 10 %. The vehicles were stopped on random sampling basis, and drivers were interviewed.

The following information was collect in the driver's interview

- Trip purpose (to home, to work, to school, at work/business, or private)
- Origin and destination
- Number of passengers (including driver)
- Estimated travel time
- Major cargo/loading factor (for truck)

5.2.2 Survey Result

(1) Number of samples and sampling rate

Number of sampling and rate at each station are shown in Table 5.2-1. Sampling rates exceeded the target of 10% at all the stations.

Table 5.2-1 Number of Sampling and Rate

Station No.	Traffic Volume (12 hrs)	No. of Sample	Sampling Rate
1	8,098	886	10.9%
3	6,144	938	15.3%
5	3,433	616	17.9%
7	10,695	1,681	15.7%
9	6,648	1,191	17.9%

(2) Average passenger occupancy

The average passenger occupancy by vehicle classification is shown in Table 5.2-2.

Table 5.2-2 Average Passenger Occupancy

Motorcycle (MC)		Light Vehicle (LV)			Heavy Vehicle (HV)		
Motorcycle and Tricycle	Motorcycle Trailer	Sedan, Wagon and Light Van	Pick-up, Jeep and Light Truck	Mini Bus	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck
1.7	4.9	3.8	4.3	8.94	35.0	2.3	2.0

(3) Major cargo and load factor

Table 5.2-3 shows the major cargo carried by trucks and trailer trucks. The cargo type was classified into ten (10) categories. Cargos in "Agriculture" and "Construction" category count for approximately 50% of whole cargos except "Others category".

Table 5.2-3 Major Cargo

Cargo	Share	
	Including Others	Excluding 'Others'
Agriculture (rice, vegetable, fruits etc.,)	23.1%	29.3%
Forest (log, timber)	1.8%	2.3%
Marine (fish seafood, fish sauce etc.,)	4.9%	6.2%
Mineral (coal, cooper etc.,)	2.9%	3.6%
Metal & Machine (steel, car , motorbike, equipment, etc.,)	5.8%	7.4%
Chemical (petroleum, etc.,)	12.0%	15.2%
Light Industry (machine parts, electronics, etc.,)	4.9%	6.2%
Miscellaneous Industry (garment shoes, etc.,)	7.9%	10.0%
Construction (sand, gravel, concrete, brick etc.,)	15.5%	19.7%
Others (water bottle, cosmetic, recycle materials(can paper, steel), animal etc.,)	21.2%	
Total	100.0%	100.0%

Figure 5.2-1 shows loading factor (percentage of actually loaded cargo against the capacity of vehicle). Approximately 40% of truck-type vehicles are fully loaded.

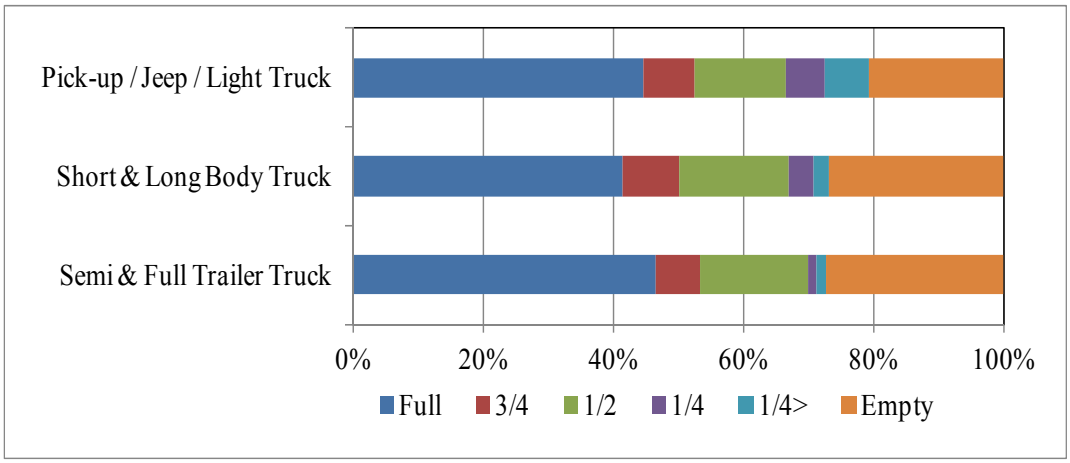


Figure 5.2-1 Loading Factor with Vehicle Classification

(4) Trip purpose

Figure 5.2-2 shows trip purpose by vehicle classification. Except Motorcycle and Tricycle, the trip purpose with the largest share is 'At Work / Business'.

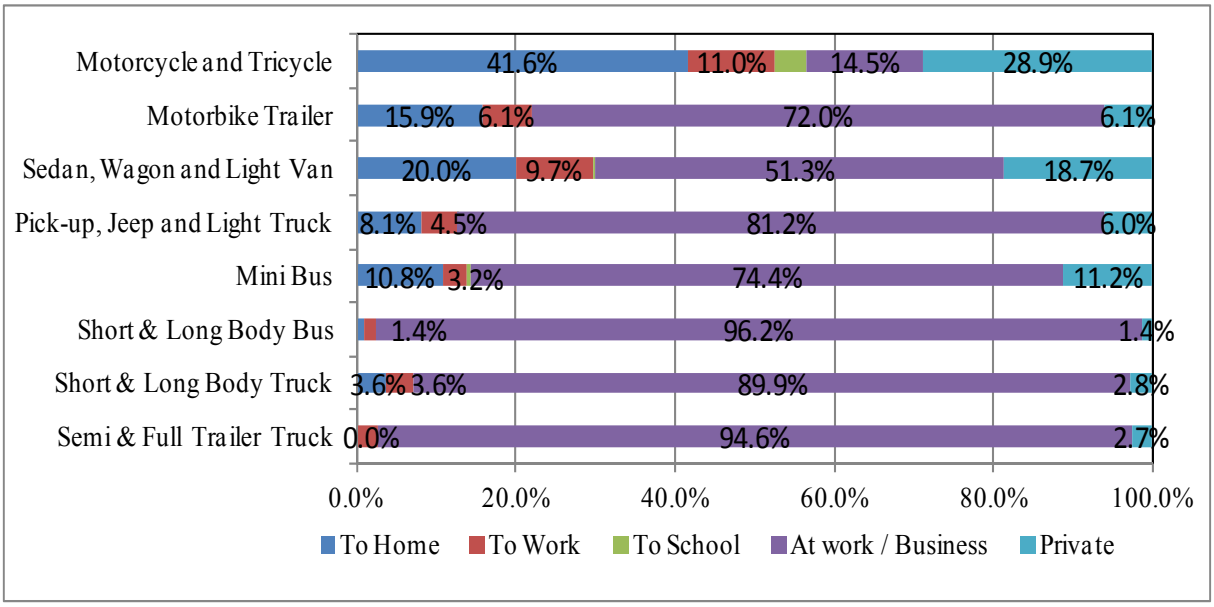


Figure 5.2-2 Trip Purpose with Vehicle Classification

(5) Travel time

Figure 5.2-3 shows the estimated average travel time by vehicle classification. The travel time from origin to destination was calculated based on estimation of driver's sense. Travel time for "Semi & full trailer truck was more than 400 minute (7 hours). However those seem to be one (1) hour shorter than actual travel time, as "short & long body bus" includes a break and truck includes loading and unloading time for category.

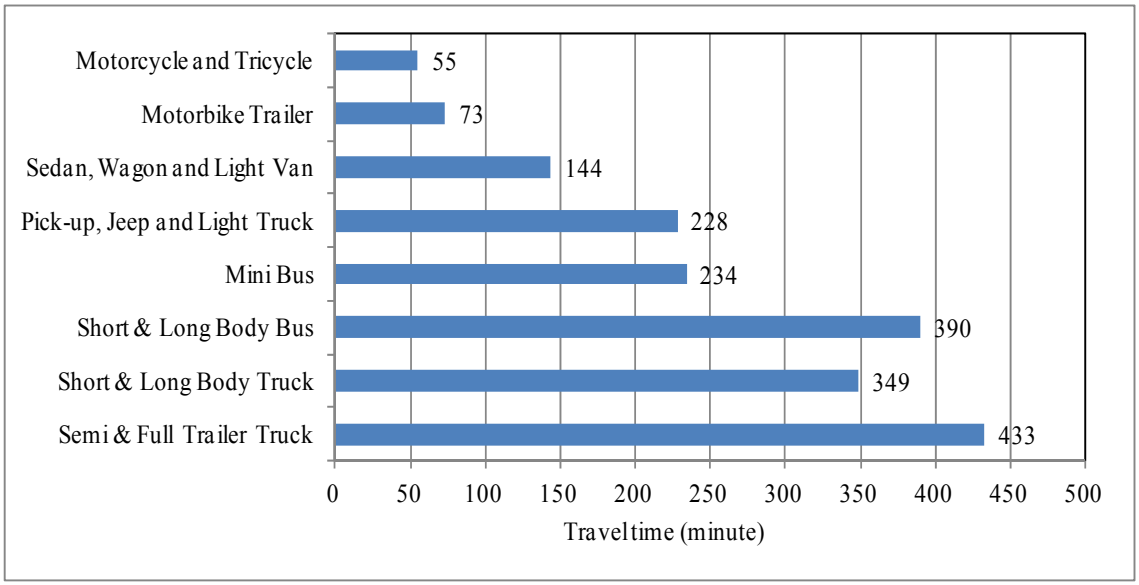


Figure 5.2-3 Estimated Average Travel Time

(6) OD trip pattern

Figure 5.2-4 shows the OD trip pattern by vehicle group in the form of desire line. Motorcycle has usually the characteristic of the short-range trip. One of the OD survey points was located at the boundary of Kampong Chhnang and Kampong Speu. There are many towns and markets in this neighborhood, and many motorcycles travel between Kampong Chhanang and Kampong Speu. In case of light vehicle, medium range trips such as between Banteay Meanchey and Battambang, and between Kampong Chhnang and Phnom Penh, as well as long-distance trips between Phnom Penh and Battmabang are prominent. As for heavy vehicles, long-distance trips such as Banteay Menchey - Phnom Penh and Battambang - Phnom Penh are eminent.

Unit: Vehicle

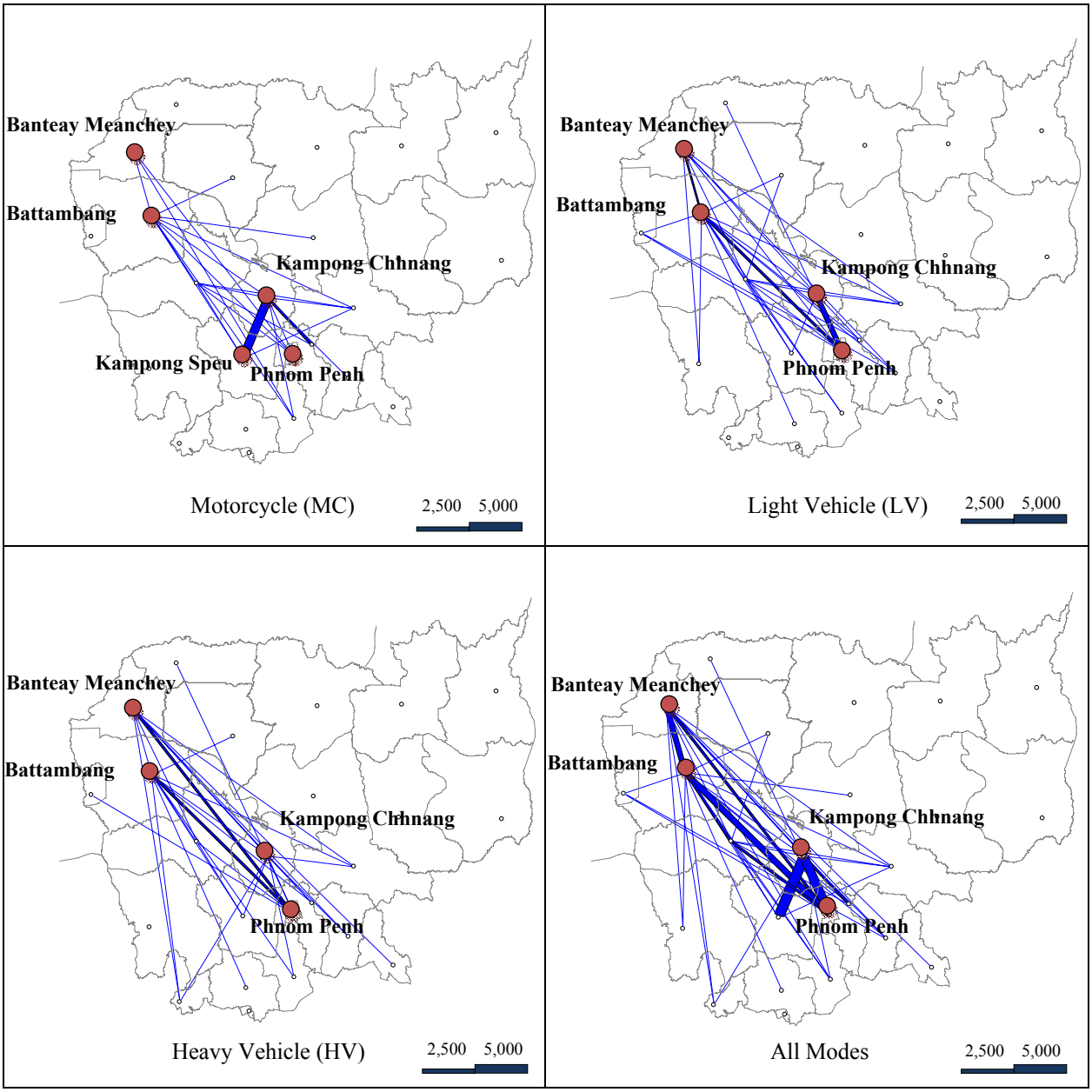


Figure 5.2-4 OD Trip Pattern

5.3 Travel Speed Survey

5.3.1 Outline

The travel speed survey was conducted from Prek Kdam Bridge to Sri Sophorn and vice versa at 7:00am on Thursday 24th of March. The whole stretch was divided into nine (9) sections and the survey was conducted by sedan car traveling at the average speed of traffic flow. In addition, the survey was conducted in Kampong Chhnang City and Battambang City in order to figure out travel speed in the urbanized area.

5.3.2 Route and Sections of Travel Speed Survey

The route and section of travel speed survey are shown in Figure 5.3-1.

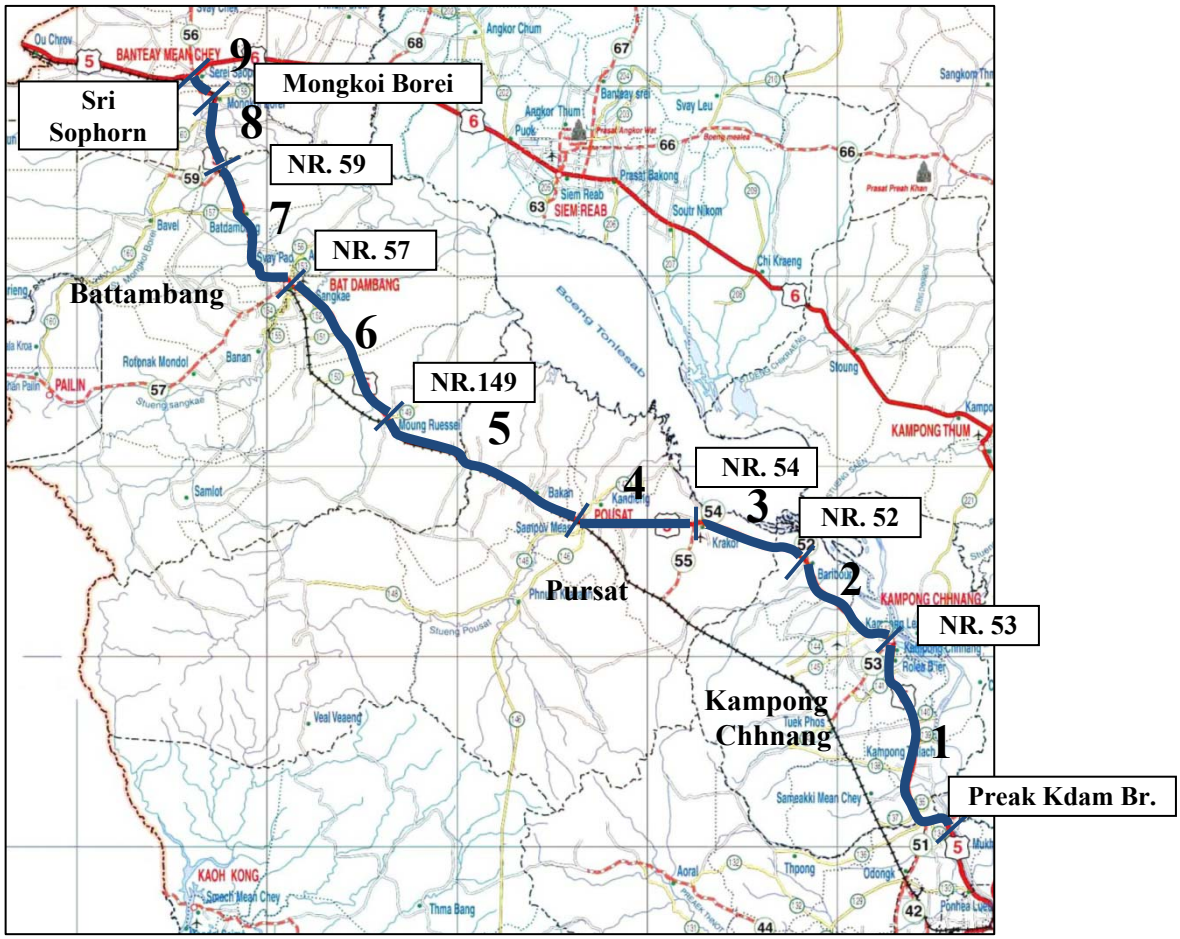


Figure 5.3-1 Travel Speed Survey Route and Section

5.3.3 Survey Result

The obtained average speed is shown in Table 5.3-1. Average travel speed between Prek Kdam and Sri Sophorn was 64.6 km/h. This speed is lower than that surveyed in the JICA Study 2005. Small reduction in the travel speed may reflect (i) deterioration of pavement and (ii) increase in traffic volume or congestion.

Table 5.3-1 Long-Distance Average Travel Speed

Section	From	To	Distance (km)	Average Speed (km/h)
1	Prek Kdam Bridge	NR 53 Jct. (Kampong Chhnang)	59.9	61.3
2	NR 53 Jct. (Kampong Chhnang)	NR 52 Jct.	32.3	62.2
3	NR 52 Jct.	NR 54 Jct.	30.0	76.7
4	NR 54.Jct	NR 148 Jct. (Prusat)	31.8	76.2
5	NR 148 Jct. (Prusat)	NR 149 (Moung Russey)	59.0	63.8
6	NR 149 (Moung Russey)	NR 57 Jct. (Battambang)	43.2	68.3
7	NR 57 Jct. (Battambang)	NR 59 Jct.	29.8	53.9
8	NR 59 Jct.	Mongkol Borei	32.3	62.8
9	Mongkol Borei	Sri Sophorn	8.5	44.3
Whole	Prek Kdam Bridge	Sri Sophorn	326.8	64.7

Travel speed survey was also conducted during the morning peak hour (8:00-8:30) in the Kampong Chhnang City and Batanmbang City. Average speeds in these cities were 49.3km and 32.4km, respectively. In the city centers, the travel speed drops to less than 30km/h and recovers to more than 40km/h when passenger car passing the city center.

Table 5.3-2 Travel Speed in Kampong Chhnang City

Section	From	To	Distance (km)	Average Speed (km/h)
1	South City Gate	Rotary (Monument)	3.60	67.7
2	Rotary (Monument)	Jct. NR 53 (City Center)	0.80	29.2
3	Jct. NR 53 (City Center)	North City Gate	2.20	41.7
Whole	South City Gate	North City Gate	6.60	49.3

Table 5.3-3 Travel Speed in Batanmbang City

Section	From	To	Distance (km)	Average Speed (km/h)
1	East City Gate	Small Rotary	0.78	34.5
2	Small Rotary	Roundabout	2.10	44.1
3	Roundabout	Bridge	2.10	40.6
4	Bridge	Rotary (City Center)	0.90	23.0
5	Rotary (City Center)	West City Gate	1.20	21.0
Whole	East City Gate	West City Gate	7.08	32.4

CHAPTER 6 FUTURE TRAFFIC DEMAND FORECAST

Forecast of the future traffic demand is the basis of highway planning and economic analysis. This chapter describes the methodology and data used in the traffic demand forecast, as well as the result of the forecast.

In the estimation of future traffic demand, target years are set at 2016, 2021 and 2030. Years 2016 and 2021 correspond to 5 and 10 years from now, and year 2030 is chosen since it will be 10 years after the long-term target year of the JICA M/P Study, 2006.

6.1 Methodology

Figure 6.1-1 shows the flow of future traffic forecast.

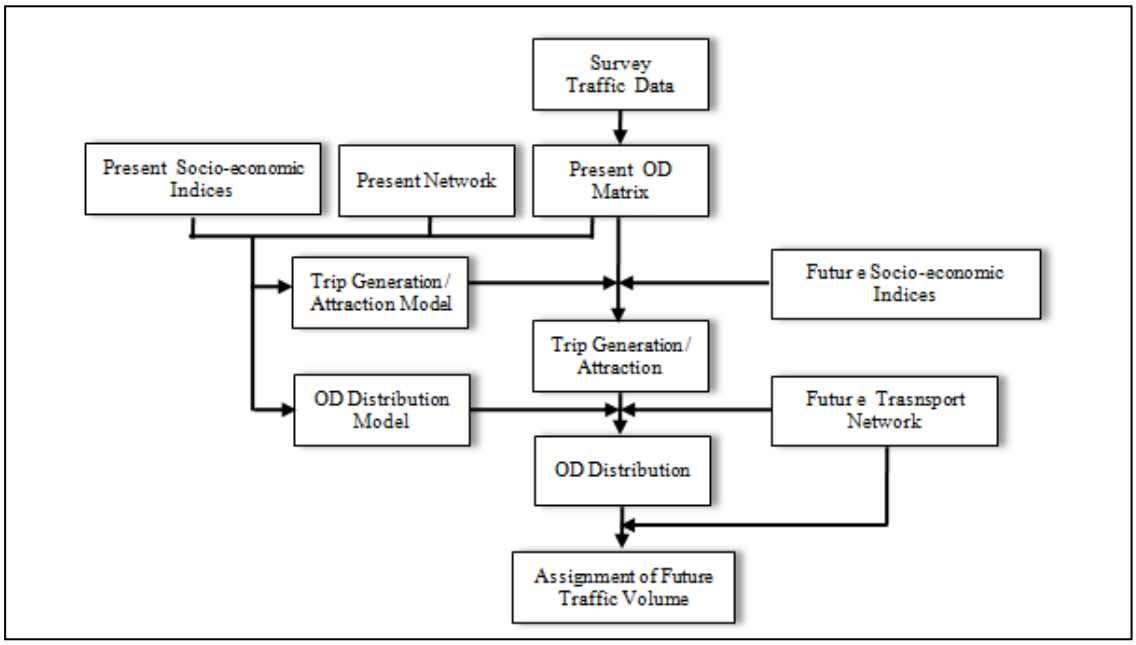


Figure 6.1-1 Flow of Traffic Demand Forecast

First, the future OD table is prepared based on the present OD table and reflecting future socio-economic indices, such as population and vehicle registration forecast. Future OD tables are forecasted through use of trip generation and attraction, and OD distribution. The future traffic demand is forecasted by assigning the future OD table onto the future network on the JICA STRADA program.

6.2 Socio-Economic Framework

Since transportation supports the social activities of the citizens and the economic activities of the industries and commerce, traffic demand is governed by socio-economic factors such as GDP, population and vehicle registration. This section describes the present conditions and

future forecast of such socio-economic factors.

6.2.1 Population Projection

"General Population Census of Cambodia 2008" published in January 2011 by the National Institute of Statistics, Ministry of Planning is the latest population projection of Cambodia. The population projection by province up to 2030 is shown in Table 6.2-1. Growth rate of whole Cambodia (country) between 2008 and 2030 is 1.33. It is noted that the growth rates of provinces in the Survey Area (Banteay Meanchey, Battambang and Pursat) are higher than that of whole country.

Table 6.2-1 Population by Province

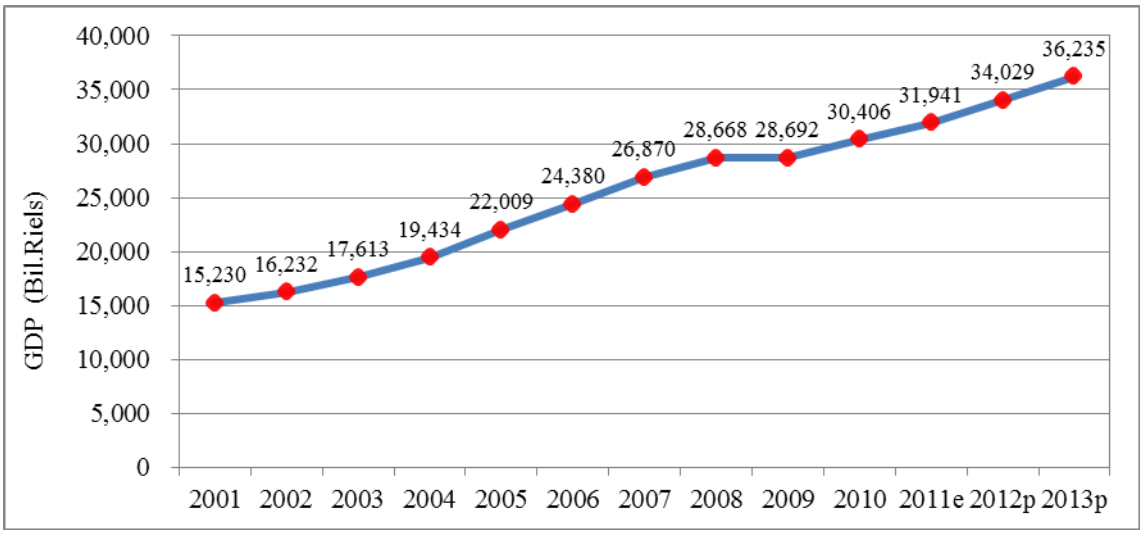
Unit: Person

Provinces	2008	2011	2016	2021	2026	2030	2030/2008
Banteay Meanchey	701,786	745,618	822,187	899,389	968,181	1,017,936	1.45
Battambang	1,061,336	1,126,345	1,238,103	1,349,178	1,449,411	1,519,185	1.43
Kampong Cham	1,739,254	1,745,054	1,739,002	1,721,623	1,689,252	1,648,438	0.95
Kampong Chhnang	488,999	512,667	549,913	583,716	611,551	628,577	1.29
Kampong Speu	742,235	767,827	804,796	837,783	865,696	882,184	1.19
Kampong Thom	653,684	668,876	688,305	705,001	718,447	724,456	1.11
Kampot	606,516	613,305	629,383	654,515	687,197	716,987	1.18
Kandal	1,309,915	1,364,065	1,463,411	1,563,607	1,653,018	1,716,290	1.31
Koh Kong	121,624	133,047	153,846	176,552	199,995	218,811	1.80
Kratie	330,480	350,566	383,382	414,756	444,084	465,960	1.41
Mondul Kiri	63,263	70,587	83,410	97,607	113,303	126,725	2.00
Phnom Penh	1,374,451	1,570,791	1,898,407	2,175,636	2,364,203	2,450,717	1.78
Preah Vihear	177,176	185,509	199,547	214,576	230,617	243,681	1.38
Prey Veng	980,790	980,667	985,036	1,006,084	1,046,198	1,089,316	1.11
Pursat	411,171	425,704	453,467	486,491	522,505	553,067	1.35
Ratanak Kiri	155,773	166,339	182,759	200,145	218,482	233,141	1.50
Siem Reap	928,065	999,703	1,120,313	1,235,423	1,339,563	1,414,727	1.52
Preah Sihanouk	229,205	247,355	279,419	311,363	340,266	360,684	1.57
Stung Treng	115,610	122,756	135,778	151,803	170,639	187,442	1.62
Svay Rieng	499,820	500,275	504,905	517,511	538,082	559,726	1.12
Takeo	874,711	877,839	889,420	916,727	957,279	997,025	1.14
Otdar Meanchey	192,375	218,786	261,201	301,968	339,134	365,010	1.90
Kep	37,016	40,142	47,945	59,427	74,433	88,797	2.40
Pailin	72,971	87,453	112,509	137,997	162,734	181,801	2.49
Cambodia	13,868,227	14,521,275	15,626,444	16,717,422	17,704,090	18,390,683	1.33

Source: National Institute of Statistics, Ministry of Planning, January 2011

6.2.2 Economic Growth of Cambodia

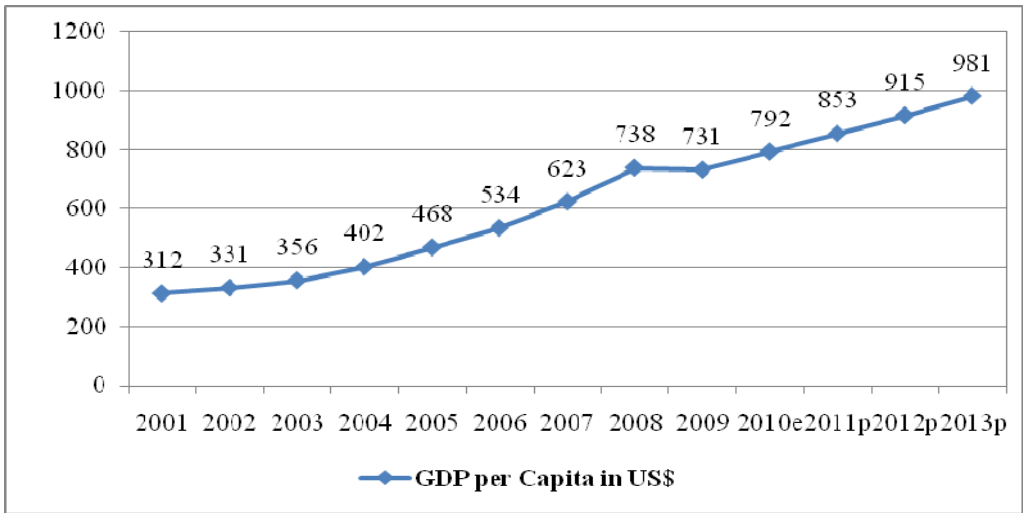
Figure 6.2-1 shows the historical trend of GDP of Cambodia in real term from 2001 to 2010 and estimated/predicted GDP from 2011 to 2013. The data show that Cambodian's economic growth rate was continuously increasing from year 2001 to 2008 with an average annual growth rate of 9.5%. Slight increase in growth rate was experienced in year 2008 to 2009 probably due to the influence of the economic trend of the world (so-called 'Lehman Shock'). It is predicted that the average annual growth rate will recover to 6.0% from year 2010 to 2013.



Note: p = predicted, e = estimated
Source: Cambodia Macroeconomic Framework 2010-2011 of Ministry of Economic and Finance, March 2010 and Mid-Term Review 2011 on National Strategic Development Plan Update 2009-2013, Ministry of Planning

Figure 6.2-1 Historical Trend of GDP Growth (2001 -2013)

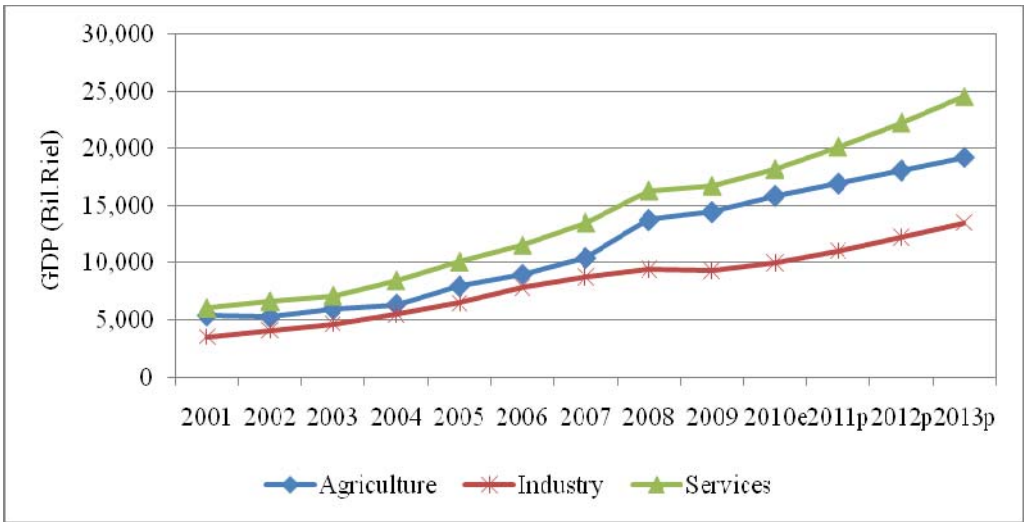
Figure 6.2-2 shows the growth of GDP per Capita. GDP per Capita increased from US$312 in 2001 to US$738 in 2008 with an average annual growth rate of 13.0%. After 2009, it is projected to increase to US$981 in year 2013.



Source: Cambodia Macroeconomic Framework 2010-2011 of Ministry of Economic and Finance

Figure 6.2-2 GDP per Capita in US$ (2001-2013)

Figure 6.2-3 shows the GDP growth rate by industry during the same periods with that of GDP Per Capita. The Cambodia's economic activities such as agriculture, industry and services keep steady increase.



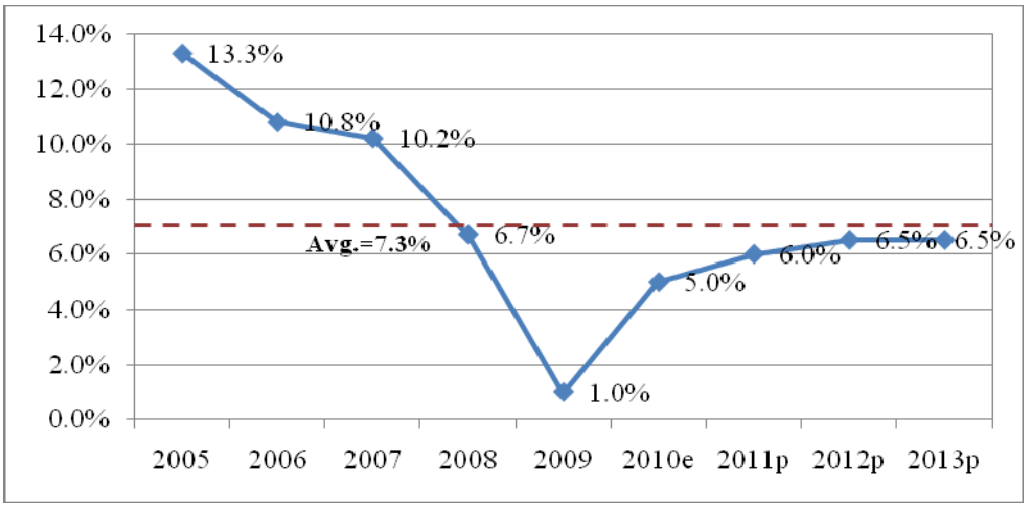
Source: Cambodia Macroeconomic Framework 2010-2011 of Ministry of Economic and Finance

Figure 6.2-3 GDP Growth by Industry (2001-2013)

6.2.3 Future GDP Prediction

(1) Past Trend

The influence of the global economic slowdown is seen in the GDP of Cambodia in 2009. However, the Cambodian economy was expected start recovering from year 2010 and an average growth rate of 6.3% is predicted for the period of 2011-2013, according to the Ministry of Economics and Finance.



Source: Cambodia Macroeconomic Framework 2010-2011 of Ministry of Economic and Finance (MEF)

Figure 6.2-4 GDP Growth 2005-2013

(2) Prediction by US Department of Agriculture

The long term (by 2030) GDP and GDP per Capita of Cambodia at constant price has been predicted by United States Department of Agriculture (USDA). According to this prediction, the annual growth rate of GDP and GDP per Capita will gradually decrease from 2013 to 2030.

Table 6.2-2 Annual Growth Rate of GDP and GDP Per Capita

Unit: %

Year	2008	2009	2010	2011	2012	2013	2016	2021	2030
GDP	6.2	-1.1	3.8	6.1	6.6	7.0	6.6	6.1	5.2
GDP per Capita	4.4	-2.83	2.0	4.3	4.8	5.2	5.0	4.6	4.1

Source: Economic Research Service, United states Department of Agriculture (USDA).

(3) Prediction Used in JICA Master Plan Study

In the report of 'the Study on the Road Network Development in the Kingdom of Cambodia', October 2006, JICA (JICA M/P Study), the GDP growth rates shown below were adopted:

Table 6.2-3 GDP Growth Rate Adopted in JICA M/P Study

Period	2006 - 2010	2011 - 2015	2016 - 2020
Growth Rate (%/Yr.)	6.0	6.9	7.8

By comparing this table with Figure 6.2-4 above, it is known that the actual growth rates for 2006 – 2008 were much higher than those predicted in the JICA M/P Study.

(4) GDP Growth Experienced in Neighboring Countries

Two neighboring countries, People's Republic of China (PRC) and Vietnam, have recently experienced, and is experiencing, rapid economic growth. These countries well may be the model of Cambodia in economic growth.

Table 6.2-4 GDP Growth Rate of PRC and Vietnam

Unit: %/Yr

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
PRC	8.4	8.3	9.1	10.0	10.1	11.3	14.2	9.6	9.2	10.3
Vietnam	6.9	7.1	7.3	7.8	8.4	8.2	8.5	6.3	5.3	6.8

Source: PRC – National Statistic Bureau of China, Vietnam – IMF

(5) Scenario of Future GDP Growth

Considering the above-stated predictions, as well as the economic growth actually happened in Cambodia in the past, three scenarios of GDP growth are assumed.

Table 6.2-5 Scenario of Future GDP Growth

Unit: %/Yr

Scenario	2011 - 2016	2017 - 2021	2022 - 2030
High Growth	8.0	7.0	6.0
Medium Growth	6.5	6.1	5.2
Low Growth	5.5	5.0	5.2

These scenarios are used in the prediction of growth of vehicle registration described below.

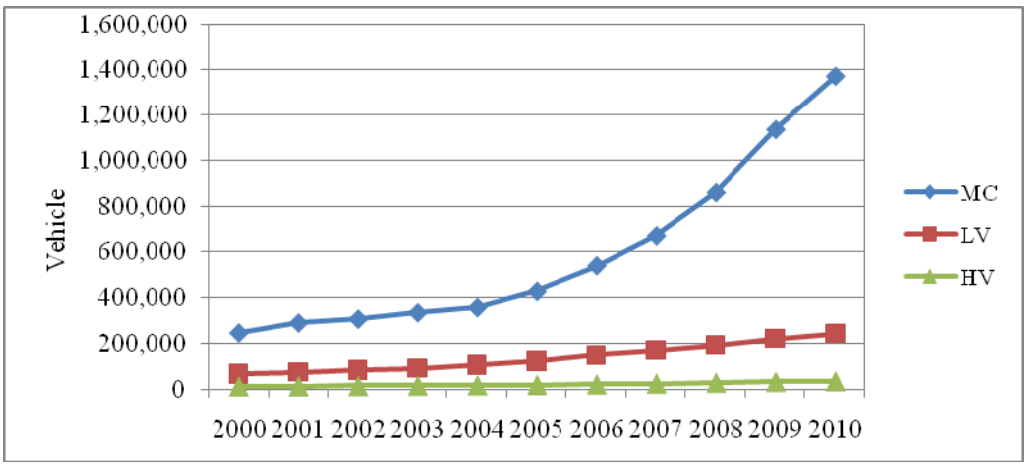
6.2.4 Vehicle Registration

(1) Trend of Vehicle Registration

Figure 6.2-5 shows trend of vehicle registration in Cambodia since 2000. Table 6.2-6 shows the recorded composition of vehicle ownership by vehicle group in 2010. Table 6.2-6 shows the number of registered vehicles as of year 2010.

The salient feature of vehicle registration in Cambodia is that the share of motorcycles (MC) is predominantly larger than those of the other vehicles. In 2010, the total number of vehicles in Cambodia accounts for 1.65 million, of which 1.37 million are MC and the remaining 0.28 million are Light vehicle (LV) and Heavy Vehicle (HV).

Average growth rates of MC, LV and HV over the period from 2000 to 2010, obtained by discarding the maximum and minimum annual growth rates, are 33%, 18% and 10%, respectively. Vehicle ownership of MC and LV per 1000 population is 96.0 and 17.0, or 1 vehicle per 10 people for MC and 1 vehicle per 59 people for LV, respectively.



Source: Ministry of Public Works and Transport

Figure 6.2-5 Trend of Vehicle Registration in Cambodia

Table 6.2-6 Vehicle Ownership in year 2010

Group	Number of vehicle	Percentage (%)
MC	1,372,252	83.0%
LV	244,267	14.8%
HV	36,015	2.2%
Total	1,652,534	100%

Source: Vehicle registration in year 2010 of Ministry of Public Work and Transport

(2) Future Vehicle Registration

Future growth rates of vehicle registration in Cambodia for the 'Medium Growth Scenario' are estimated as shown in Table 6.2-7 were estimated considering and/or assuming the following:

- Although the growth rate of motorcycles in Cambodia was very high (more than 33%, 18% and 10 % for MC, LV and HV, respectively) in the past few years, probably owing to very high rate (more than 10%) of economic growth recorded in years 2005 – 2007, it should become smaller as the growth rate of economy becomes stable at around 6%.

- It is assumed that people tend to shift from MC to LV as GDP per capita increases, or income level goes up. Thus, the decrease of the growth rate of MC in the future will be larger than that of LV.

- Demand for HV will increase as the economy grows because transportation by HV is necessary for the economic activity. Thus, the growth rates of vehicle registration by vehicle type are estimated as shown in Table 6.2-7.

Table 6.2-7 Growth Rate of Vehicle Registration

Year	Growth Rate of Vehicle Registration (%/yr)		
	MC	LV	HV
2000 – 2010 (Trimmed Average)	33	18	10
2010	21	10	7
2011	17	15	10
2012	14	12	10
2013	12	10	10
2014	10	8	8
2015	9	7	7
2016 – 2020	8-4	6	6
2021 – 2026	3-2	5	5
2027 – 2030	1	4	4

Figure 6.2-6 shows the future growth of vehicle registration, as well as growth of past 10 years.

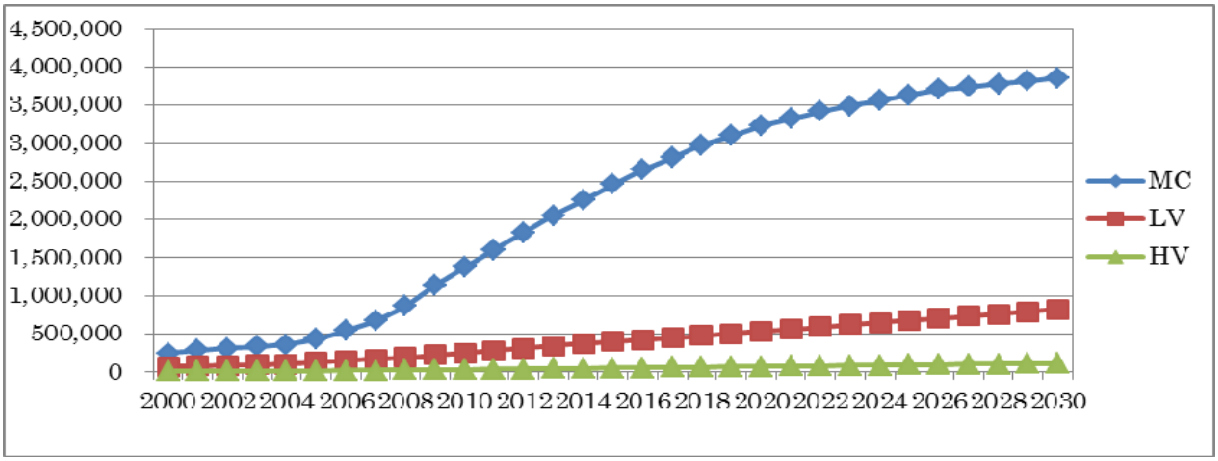


Figure 6.2-6 Projection of Number of Vehicles

Table 6.2-8 shows the projected number of vehicle registration in years 2011, 2016, 2021 and 2030.

Table 6.2-8 Projection of Number of Vehicle

Group	2011	2016	2021	2030
MC	1,605,535	2,654,517	3,322,777	3,855,002
LV	280,907	423,923	561,952	823,128
HV	39,617	58,718	77,837	114,013
Total	1,926,058	3,137,158	3,962,567	4,792,143

If this estimation becomes reality, ratio of number of people per one vehicle, including MC, is to become 3.8 persons/vehicle, or 1.25 vehicle/household, in year 2030. For reference, this ratio is approximately 1.8 persons/vehicle in Japan now. In case of Japan percentage of MC is much smaller (4.5%, excluding those with engine smaller than 50 cc) than that in Cambodia.

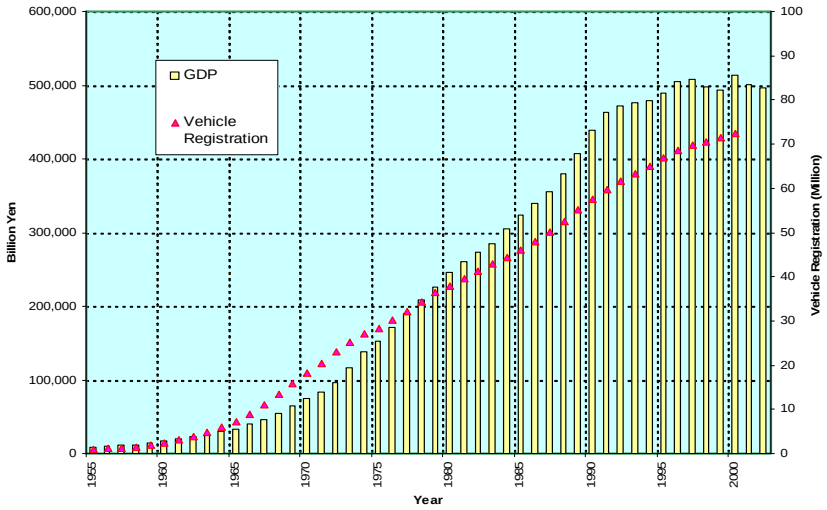


Figure 6.2-7 Increase of Vehicle Registration in Japan in the Past

In case of Vietnam, the total number of MC reached 19 million or 4.5 person/veh in 2006. This is comparable to 4.7 person/veh of MC in Cambodia projected in 2030.

Figure 6.2-8 shows the projected growth of vehicle registration for the three scenarios of GDP growth as in Subsection 6.2.3 above. In case of the 'High Growth Scenario', the total number of registered vehicle is projected to reach 6,547,000, or 2.8 person/veh, in 2030. Compared to the figures of Vietnam and Japan, this figure is considered to be too large. Thus, the figure of the 'Medium Growth Scenario' is adopted.

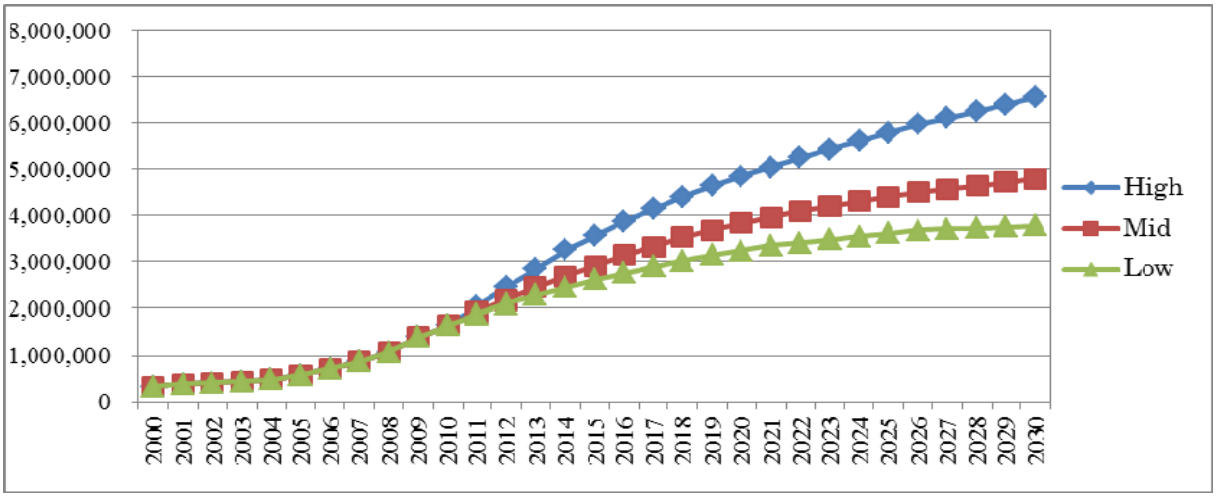


Figure 6.2-8 Projection of Number of Vehicles for Three Scenarios of GDP Growth

6.3 Future OD Table

6.3.1 Zoning System

The OD zoning system used the JICA M/P Study is also used in this Survey. The total number of zones is 197 (185 zones within Cambodia and 12 zones outside of Cambodia). Table 6.3-1 shows the list of OD zones.

Table 6.3-1 Zoning Code

Province	Zone No	District	Traffic Zone
Banteay Meanchey	1	Mongkol Barei	1
		Phnum Srok	2
		Preah Netr Preah	3
		Ou Chrov	4
		Serei Saophoan	5
		Thma Puok	6
		Svay Chek	7
		Malai	8
Battambang	2	Banan	9
		Thma Koul	10
		Bat Dambang	11
		Bavel	12
		Aek Phnum	13
		Moung Ruessei	14
		Rotanak Mondol	15
		Sangkae	16
		Samlout	17
		Sampov Lun	18
		Phnum Proek	19
		Kamrieng	20
		Koas Krala	21
Kampong Cham	3	Batheay	22
		Chamkar Leu	23
		Cheung Prey	24
		Dambae	25
		Kampong Cham	26
		Kampong Siem	27
		Kang Meas	28
		Kaoh Soutin	29
		Krouch Chhmar	30
		Memot	31
		Ou Reang Ov	32
		Ponhea Kraek	33
		Prey Chhor	34
		Srei Santhor	35
		Stueng Trang	36
		Tboung Khmum	37
Kampong Chhnang	4	Baribour	38
		Chol Kiri	39
		Kampong Chhnang	40
		Kampong Leaeng	41
		Kampong Tralach	42
		Rolea B'ier	43
		Sameakki Mean Chey	44
		Tuek Phos	45
Kampong Speu	5	Basedth	46
		Chbar Mon	47
		Kong Pisei	48
		Aoral	49
		Odongk	50
		Phnum Sruoch	51
		Samraong Tong	52
		Thpong	53
Kampong Thom	6	Baray	54
		Kampong Svay	55
		Stueng Saen	56
		Prasat Balangk	57
		Prasat Sambour	58
		Sandan	59
		Santuk	60
		Stoung	61
Kampot	7	Angkor Chey	62
		Banteay Meas	63
		Chhuk	64
		Chum Kiri	65
		Dang Tong	66
		Kampong Trach	67
		Kampot	68
		Kampong Bay	69
Kandal	8	Kandal Stueng	70
		Kien Svay	71
		Khsach Kandal	72
		Kaoh Thum	73
		Leuk Daek	74
		Lvea Aem	75
		Mukh Kampul	76
		Angk Snuol	77
		Ponhea Lueu	78
		S'ang	79
		Ta Khmau	80
Koh Kong	9	Botum Sakor	81
		Kiri Sakor	82
		Kaoh Kong	83
		Smach Mean Chey	84
		Mondol Seima	85
		Srae Ambel	86
		Thma Bang	87
		Kampong Seila	88
Kratie	10	Chhloung	89
		Kracheh	90
		Preaek Prasab	91
		Sambour	92
		Snoul	93
Mondul Kiri	11	Kaev Seima	94
		Kaoh Nheaek	95
		Ou Reang	96
		Pechr Chenda	97
		Saen Monourom	98
Phnom Penh	12	Chamkar Mon	99
		Doun Penh	100
		Prampir Meakkara	101
		Tuol Kouk	102
		Dangkao	103
		Mean Chey	104
		Ruessei Kaev	105

Province	Zone No	District	Traffic Zone
Preah Vihear	13	Chey Saen	106
		Chhaeb	107
		Choam Khsant	108
		Kuleaen	109
		Rovieng	110
		Sangkom Thmei	111
		Tbaeng Mean Chey	112
Prey Veng	14	Ba Phnum	113
		Kamchay Mear	114
		Kampong Trabaek	115
		Kanhchriech	116
		Me Sang	117
		Peam Chor	118
		Peam Ro	119
		Pea Reang	120
		Preah Sdach	121
		Prey Veaeng	122
		Kampong Leav	123
		Sithor Kandal	124
Pursat	15	Bakan	125
		Kandieng	126
		Krakor	127
		Phnum Kravanh	128
		Sampov Meas	129
		Veal Veaeng	130
Ratanak Kiri	16	Andoung Meas	131
		Ban Lung	132
		Bar Kaev	133
		Koun Mom	134
		Lumphat	135
		Ou Chum	136
		Ou Ya Dav	137
		Ta Veaeng	138
		Veun Sai	139
Siemreap	17	Angkor Chum	140
		Angkor Thum	141
		Banteay Srei	142
		Chi Kraeng	143
		Kralanh	144
		Puok	145
		Prasat Bakong	146
		Siem Reab	147
		Soutr Nikom	148
		Srei Snam	149
		Svay Leu	150
		Varin	151
Sihanoukville	18	Mittakpheap	152
		Prey Nob	153
		Stueng Hav	154
Stung Treng	19	Sesan	155
		Siem Bouk	156
		Siem Pang	157
		Stueng Traeng	158
		Thala Barivat	159
Svay Rieng	20	Chantrea	160
		Kampong Rou	161
		Rumduol	162
		Romeas Haek	163
		Svay Chrum	164
		Svay Rieng	165
		Svay Teab	166
Takeo	21	Angkor Borei	167
		Bati	168
		Bourei Cholsar	169
		Kiri Vong	170
		Kaoh Andaet	171
		Prey Kabbas	172
		Samraong	173
		Doun Kaev	174
		Tram Kak	175
		Treang	176
Oddar Meanchey	22	Anlong Veaeng	177
		Banteay Ampil	178
		Chong Kal	179
		Samraong	180
		Trapeang Prasat	181
Kep	23	Damnak Chang'aeur	182
		Kaeb	183
Pailin	24	Pailin	184
		Sala Krau	185
Laos	25	NR7	186
Thailand	26	NR5	187
	27	NR48	188
	28	NR57	189
	29	NR67	190
	30	NR68	191
Vietnam	31	NR1	192
	32	NR2	193
	33	NR21	194
	34	NR33	195
	35	NR72	196
	36	NR76	197

6.3.2 Preparation of Present OD table

OD table of year 2010 used in the JICA M/P Study 2006 was adopted as the basis of the present OD table of this Survey. It was adjusted based on the results of OD survey conducted in this Survey, focusing the traffic along NR 5.

6.3.3 Trip Generation and Attraction

Future OD matrices were estimated by the Frator method using the present OD matrix and the estimated trip generation and attraction. Future trip generation/attraction was estimated by incorporating the future growth of population and vehicle registration as described in Section 6.2 above. Present and future trip generation and attraction by vehicle type for the years 2011, 2016, 2021 and 2030 are shown in Table 6.3-2 (1) to Table 6.3-2 (4).

Table 6.3-2 (1) Trip Generation and Attraction by Vehicle Type Group in 2011

Unit: Vehicle/day

Zone No.	Province	Trip Generation in 2011			Trip Attraction in 2011		
		MC	LV	HV	MC	LV	HV
1	Banteay Meanchey	6,446	2,929	1,147	6,303	3,247	1,040
2	Battambang	23,505	3,448	1,341	23,701	3,743	1,591
4	Kampong Chhnang	9,299	2,482	339	8,578	2,752	411
12	Phnom Penh	50,588	22,848	5,191	50,920	21,821	5,164
15	Pursat	1,521	398	236	1,534	498	273

Table 6.3-2 (2) Trip Generation and Attraction by Vehicle Type Group in 2016

Unit: Vehicle/day

Zone No.	Province	Trip Generation in 2016			Trip Attraction in 2016		
		MC	LV	HV	MC	LV	HV
1	Banteay Meanchey	10,816	4,024	1,557	10,573	4,482	1,412
2	Battambang	39,936	4,724	1,808	40,252	5,153	2,145
4	Kampong Chhnang	14,063	3,264	441	12,974	3,642	534
12	Phnom Penh	90,844	39,560	8,144	91,330	37,917	8,109
15	Pursat	2,418	521	314	2,439	656	363

Table 6.3-2 (3) Trip Generation and Attraction by Vehicle Type Group in 2021

Unit: Vehicle/day

Zone No.	Province	Trip Generation in 2021			Trip Attraction in2021		
		MC	LV	HV	MC	LV	HV
1	Banteay Meanchey	17,649	5,537	2,082	17,249	6,189	1,888
2	Battambang	65,398	6,480	2,406	65,903	7,092	2,854
4	Kampong Chhnang	21,943	4,312	568	20,247	4,830	689
12	Phnom Penh	151,570	62,586	11,853	152,303	60,158	11,811
15	Pursat	3,868	697	416	3,902	880	481

Table 6.3-2 (4) Trip Generation and Attraction by Vehicle Type Group in 2030

Unit: Vehicle/day

Zone No.	Province	Trip Generation in 2030			Trip Attraction in 2030		
		MC	LV	HV	MC	LV	HV
1	Banteay Meanchey	27,567	7,145	2,659	26,938	8,020	2,411
2	Battambang	102,090	8,329	3,052	102,860	9,153	3,621
4	Kampong Chhnang	33,362	5,210	690	30,787	5,867	837
12	Phnom Penh	237,020	96,186	16,624	238,120	92,788	16,581
15	Pursat	6,042	886	534	6,094	1,126	617

Figure 6.3-1 (1) to Figure 6.3-1 (4) (in the following pages) show the total trip production (total of generation and attraction) by zone in 2011, 2016, 2021 and 2030.

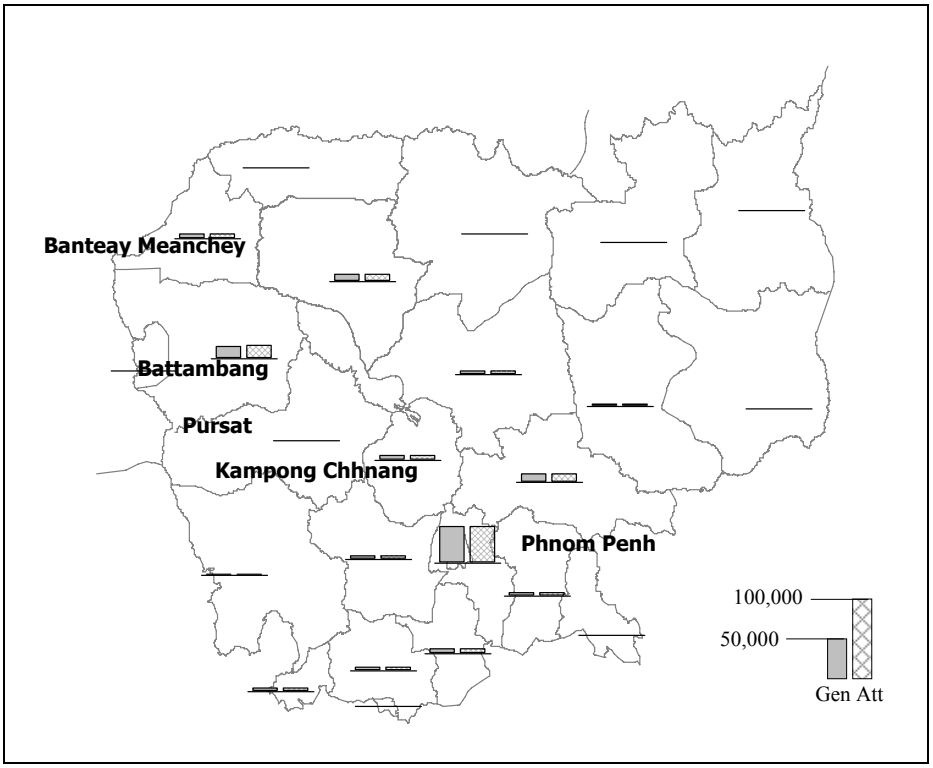


Figure 6.3-1 (1) Total Trip Production in 2011 (Total Vehicle)

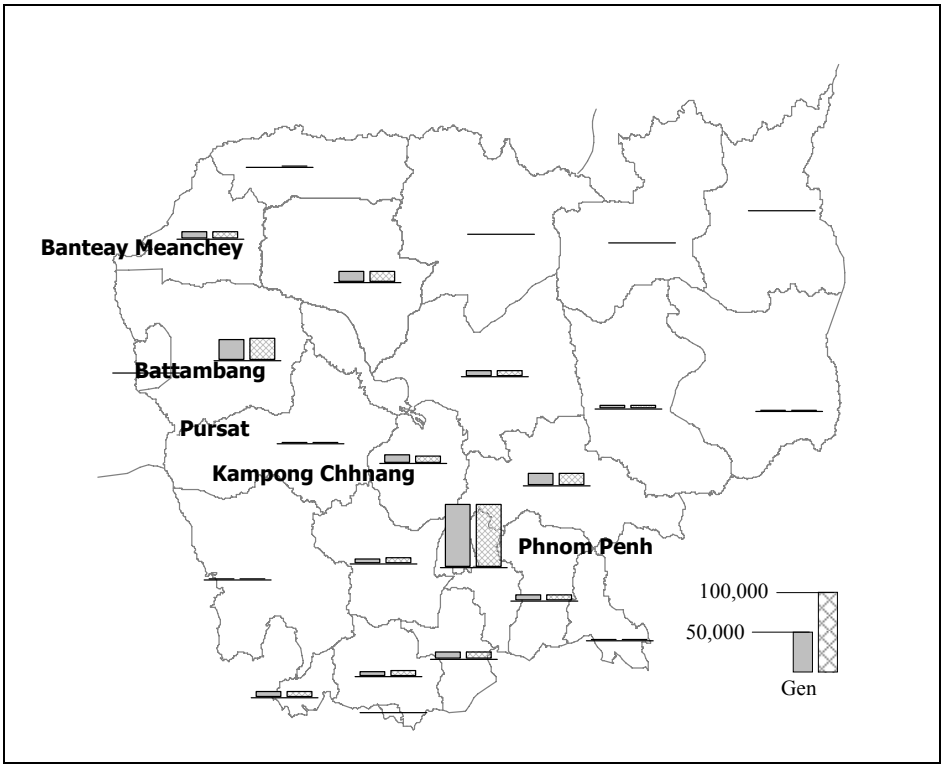


Figure 6.3-1 (2) Total Trip Production in 2016 (Total Vehicle)

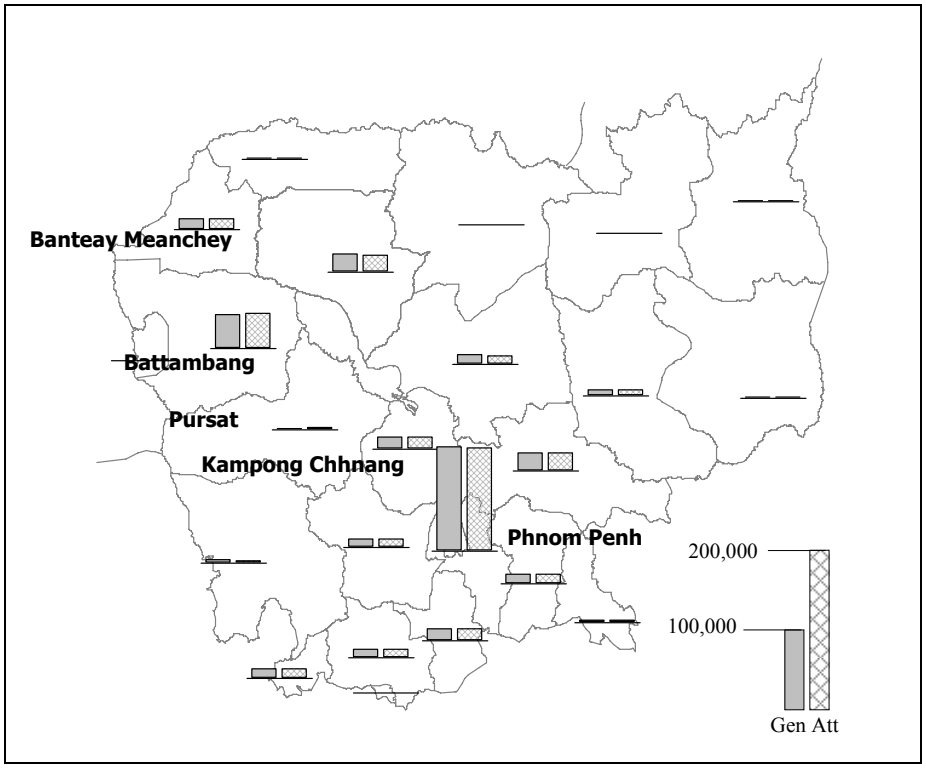


Figure 6.3-1 (3) Total Trip Production in 2021 (Total Vehicle)

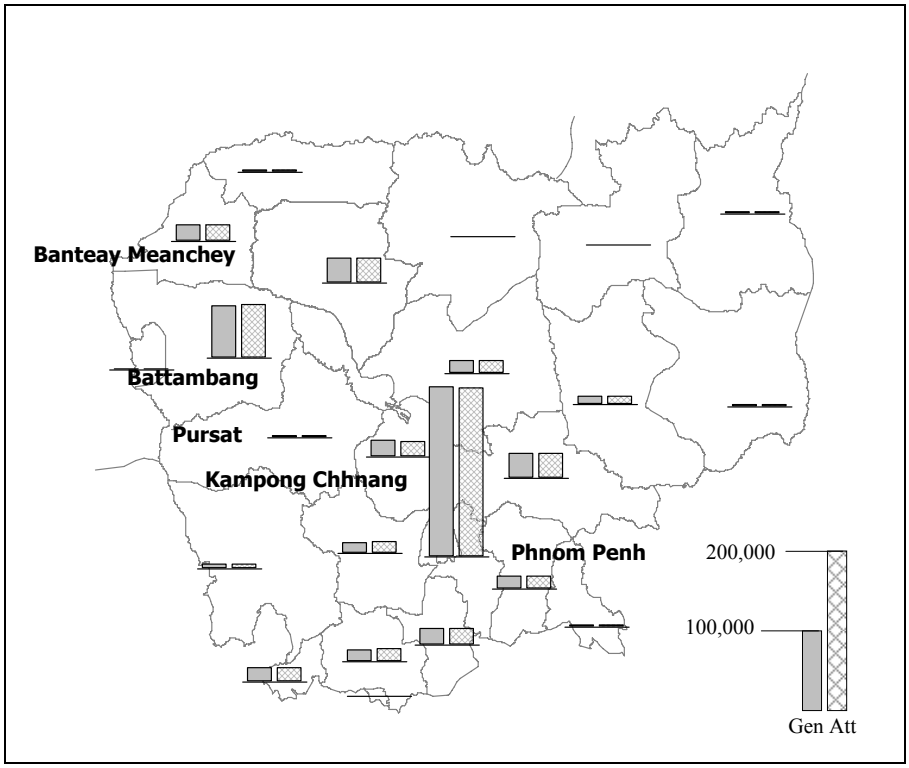


Figure 6.3-1 (4) Total Trip Production in 2030 (Total Vehicle)

6.3.4 Modal Split

(1) Railroad

A railroad line (North Line) between Poipet and Phnom Penh, is running in parallel to NR 5. This railroad is currently being rehabilitated with a financial assistance of ADB. In this rehabilitation plan, 5 times a day of train operation is assumed in the future. However, type and volume of cargo to be transported by the railroad is not known at present. Therefore, diversion of cargo nor passenger from automobile to railroad is not taken into account in this traffic forecast, but considered in overall examination of forecasted traffic volume presented in Item (3) of Subsection 6.4.1 below.

(2) Bus Service

Many long-distance bus services are available on NR 5. It is not conceivable that the share of transport by such long-distance buses greatly increase in the future as the income level of the people will be upgraded. Therefore, diversion to long-distance bus service is not taken into account in this future traffic demand forecast.

(3) Inland Water Transport

An agreement to promote inland water transport was signed between the RGC and the government of Vietnam in December 2009. This will encourage the inland water transport along Mekong River, Tonle Sap River, Tonle Sap Lake and Bassac River. However the diversion of cargo or passenger from NR 5 to such inland water transport is considered to be limited. Thus, such diversion is not considered in this traffic forecast.

6.4 Traffic Demand Forecast

6.4.1 Traffic Assignment

(1) Methodology and Result

Traffic volume by road section in the future was estimated by traffic assignment program of JICA STRADA. JICA STRADA adopts 'the minimum paths method' in which the vehicles are assumed to take the path with the minimum cost (sum of travel time cost and vehicle operation cost) among the road links of the network connecting the pair of OD zones. Figure 6.4-1 (1) to Figure 6.4-1 (4) show the result of the traffic assignment for year 2016 and 2030.

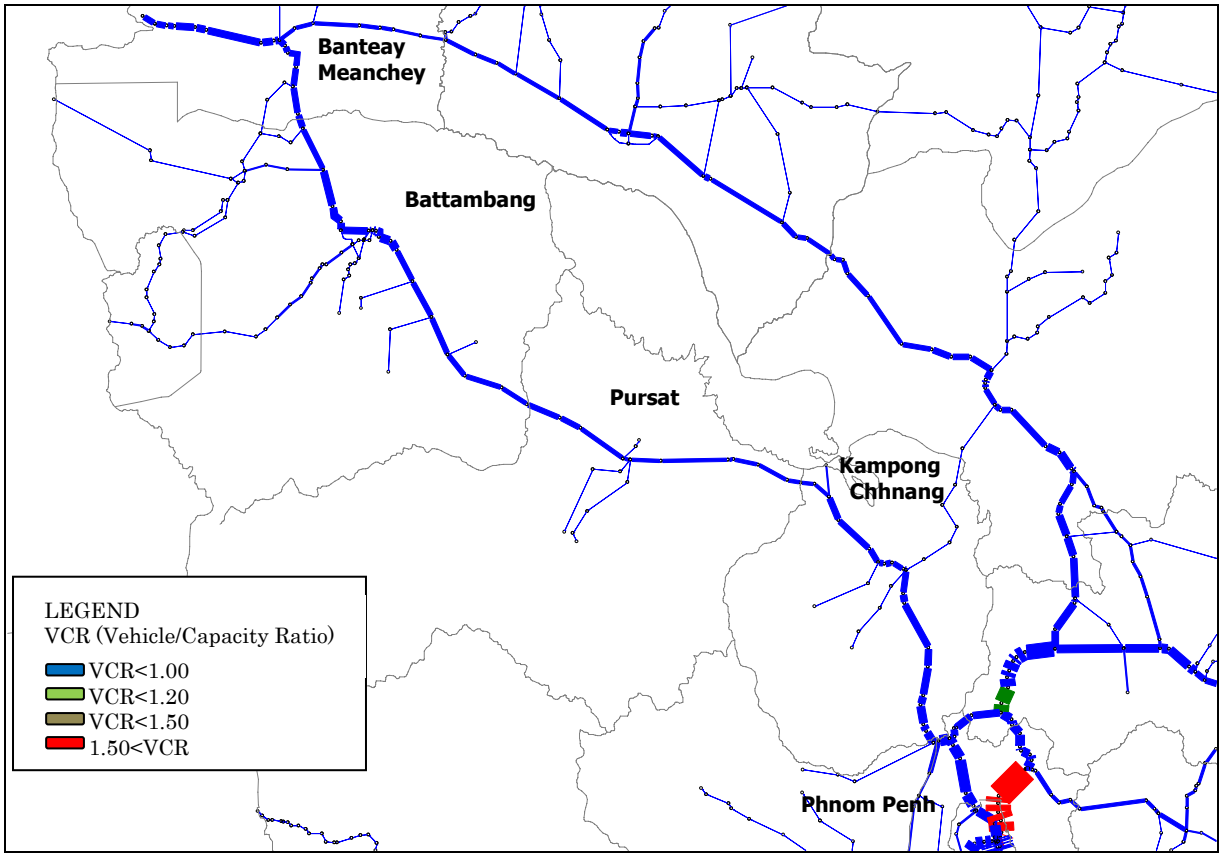


Figure 6.4-1 (1) Result of Traffic Assignment for Year 2011

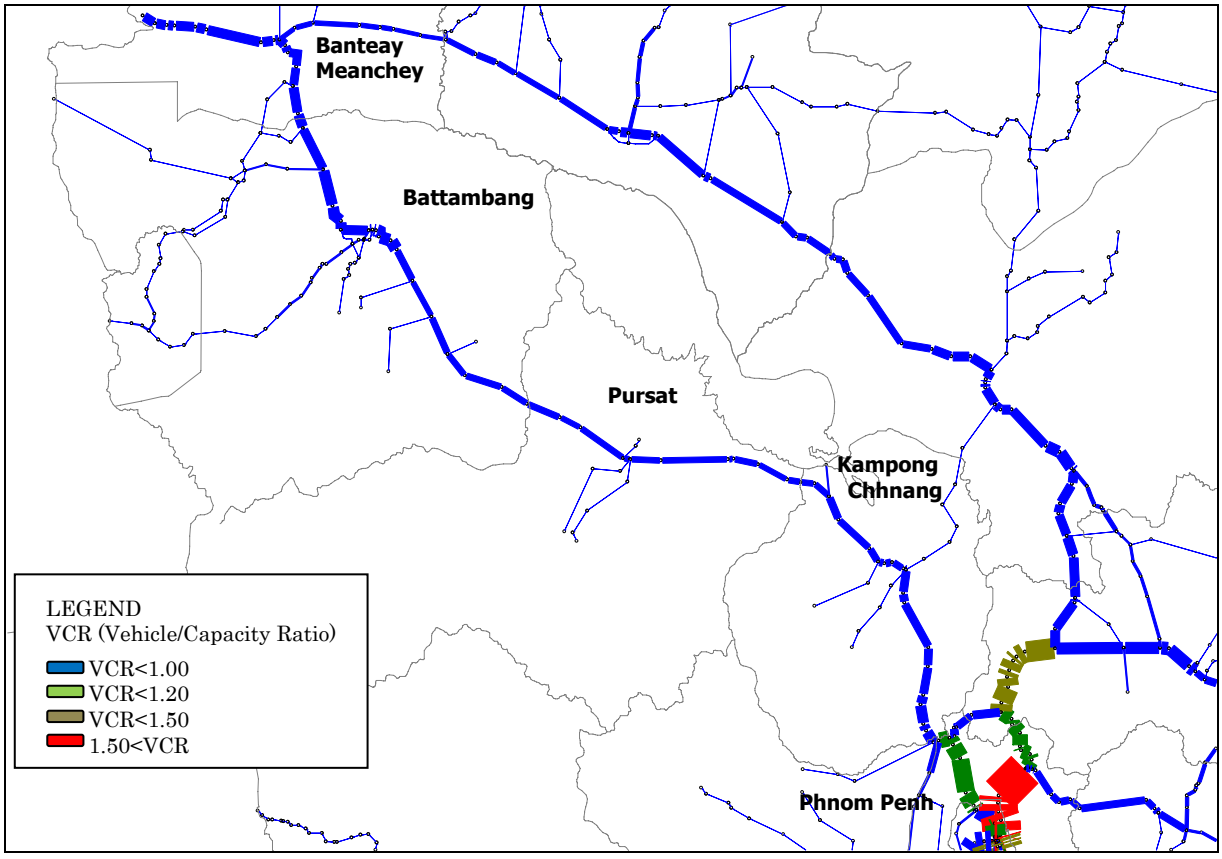


Figure 6.4-1 (2) Result of Traffic Assignment for Year 2016

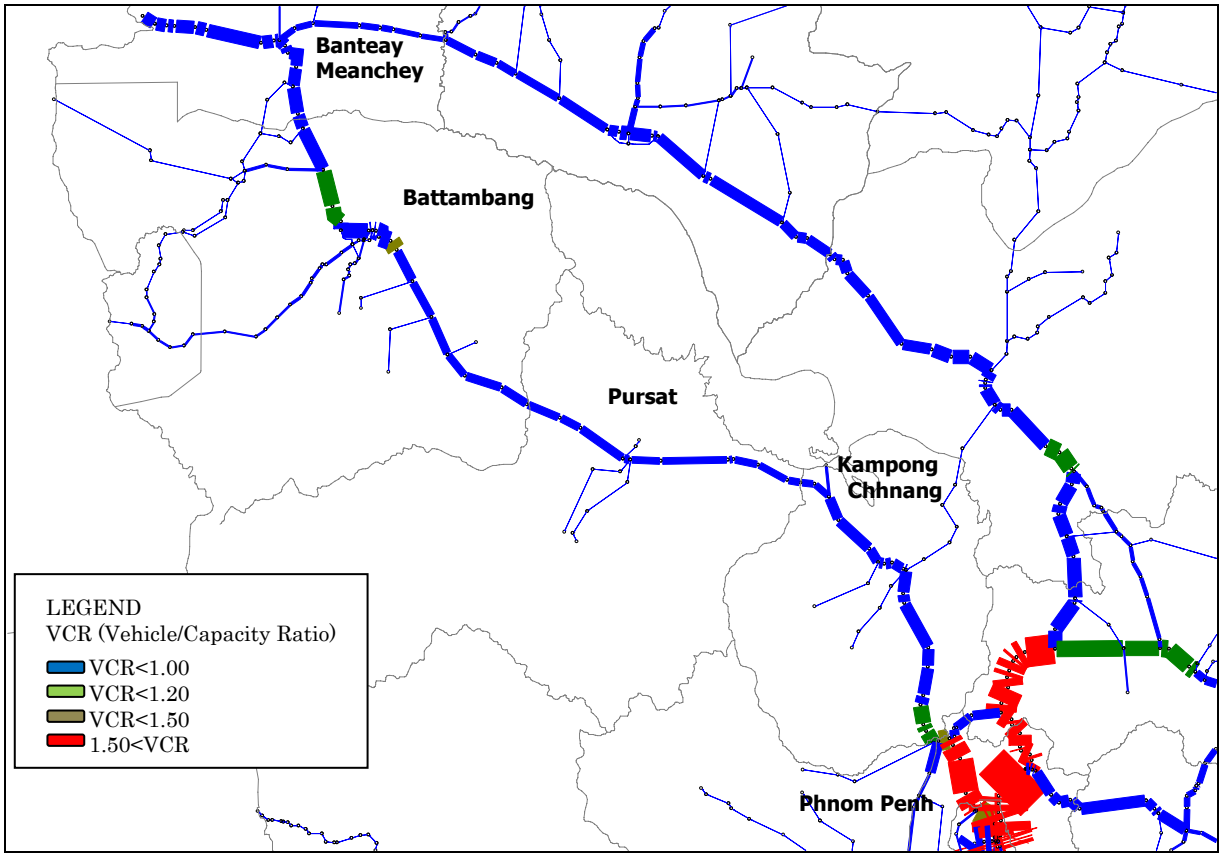


Figure 6.4-1 (3) Result of Traffic Assignment for Year 2021

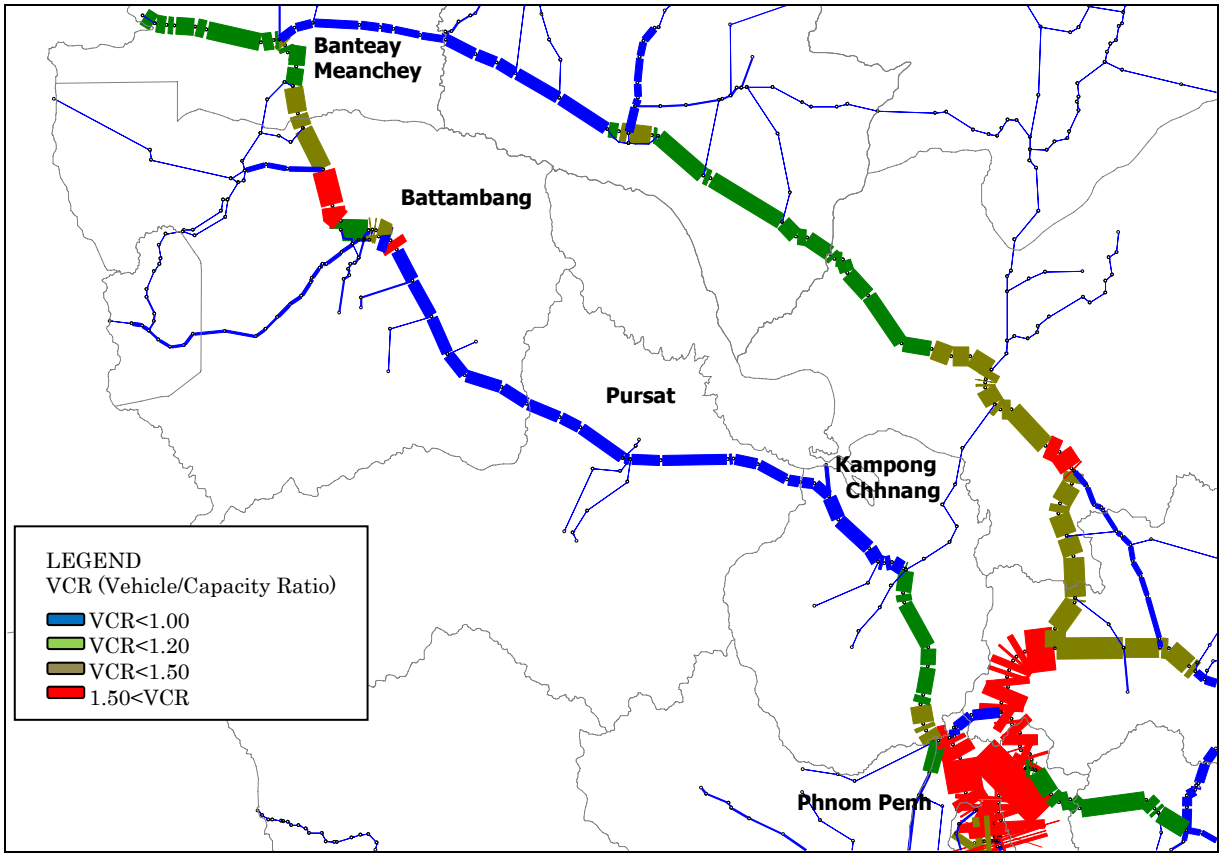


Figure 6.4-1 (4) Result of Traffic Assignment for Year 2030

Passenger Car Unit

In the traffic assignment, traffic volume is expressed in the form 'Passenger Car Unit' (PCU). The PCU equivalents used in this study are shown below.

Categories	MC	LV	HV
PCU Equivalents	0.30	1.25	3.00

Usually, PCU of sedan and pick-up truck is set at 1.0. In this Survey, PCU of Light Vehicle (LV) is set at 1.25 considering that this category includes light truck and pick-up truck whose speed are slower than passenger cars because of cargo and contribution to traffic congestion is larger than ordinary passenger car.

Table 6.4-1 lists the forecasted traffic volumes for years 2011, 2016, 2021 and 2030 at the traffic counting stations stated in Chapter 5. Traffic volumes by vehicle type for each target year are shown in Table 6.4-2.

Table 6.4-1 Result of Traffic Assignment

Unit: PCU

Section	Station No.	Year			
		2011	2016	2021	2030
South	1	10,612	14,720	20,641	28,637
	2	8,644	11,519	15,735	21,164
	3	7,426	10,001	13,775	18,947
	4	5,616	7,453	10,092	13,888
Middle (Boundary)	5	6,071	8,232	11,368	15,899
	6	12,052	17,556	25,625	36,834
North	7	9,065	13,545	20,090	29,464
	8	8,453	12,356	17,812	25,540
	9	8,983	12,734	17,794	23,861

Table 6.4-2 Traffic Volume by Vehicle Type

Unit: Veh.

Section	Station No.	2011					2016				
		MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
South	1	5,797	3,520	1,491	10,808	10,612	8,907	4,706	2,055	15,668	14,720
	2	3,677	3,347	1,119	8,143	8,644	5,643	4,146	1,556	11,346	11,544
	3	3,890	2,298	1,129	7,317	7,426	5,977	2,770	1,587	10,334	10,017
	4	690	1,781	1,061	3,532	5,616	1,137	2,104	1,494	4,735	7,453
Middle (Boundary)	5	1,380	2,308	924	4,612	6,071	2,327	2,830	1,332	6,489	8,232
	6	12,523	3,250	1,411	17,184	12,052	21,263	4,168	1,989	27,420	17,556
North	7	8,807	3,297	734	12,837	8,965	15,030	4,646	1,096	20,772	13,605
	8	4,617	2,374	1,367	8,357	8,453	7,803	3,356	1,940	13,099	12,356
	9	3,903	3,636	1,089	8,628	8,983	6,403	5,542	1,505	13,451	13,364

Section	Station No.	2021					2030				
		MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
South	1	13,880	6,464	2,799	23,143	20,641	21,003	9,027	3,684	33,715	28,637
	2	8,763	5,337	2,145	16,245	15,735	13,220	6,863	2,873	22,956	21,164
	3	9,297	3,530	2,191	15,018	13,775	14,033	4,729	2,942	21,704	18,947
	4	1,737	2,672	2,077	6,486	10,092	2,537	3,772	2,804	9,113	13,888
Middle (Boundary)	5	3,693	3,672	1,890	9,255	11,368	5,623	5,106	2,610	13,339	15,899
	6	34,713	5,554	2,756	43,024	25,625	54,063	7,612	3,700	65,375	36,834
North	7	24,647	6,492	1,527	32,666	20,090	38,560	9,253	2,110	49,923	29,464
	8	12,700	4,827	2,656	20,183	17,812	19,807	7,242	3,514	30,562	25,536
	9	10,220	6,970	2,005	19,195	17,794	15,700	9,162	2,566	27,428	23,861

(2) Verification of Result of Traffic Forecast

In order to verify the accuracy of the traffic volumes estimated by the above-described method, the estimated traffic volumes of 2011 at traffic counting stations, as shown in Table 6.4-1 above, are compared with the actually observed traffic volumes. Figure 6.4-2 shows the result of comparison. The figure indicates overall agreement between the estimated values and actually observed values, with a tendency that the estimated values are slightly smaller than observed values.

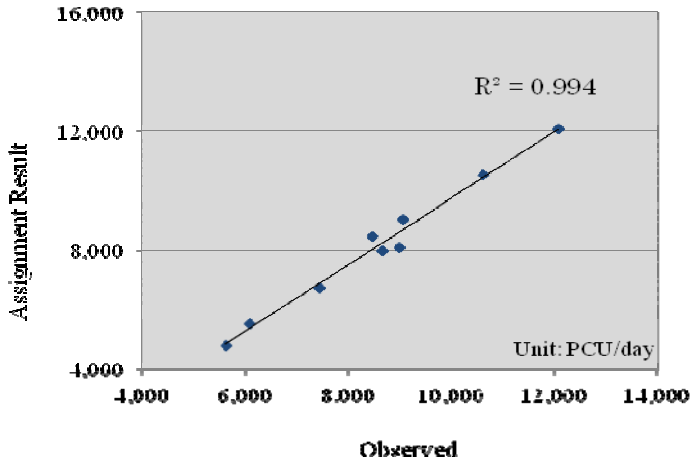


Figure 6.4-2 Verification Between Assignment Result and Actual Traffic Count

(3) Overall Examination of Forecasted Traffic Volume

As stated before, rehabilitation of the North Line of railroad is being implemented. Also, the plan of constructing a new road between Battambang and Siem Reap has recently been discussed. Ii is difficult to estimate the influences of these projects on the traffic demand of NR 5 since operation plan of railroad and route of the new road are not fixed yet. However, the influences of these projects are examined to see if there is any need of adjustment in overall plan of improvement of NR 5.

(i) Influence of Railroad

Based on the experiences of Japan, USA and European countries, as well as considering the routes and other conditions of rail transport and NR 5, the followings are assumed for estimation of diversion from road to railroad:

- ✓ Traffic of heavy vehicles with trip length longer than 100 km is considered to be possibly subject to diversion to rail transport.
- ✓ Considering modal shares of road and rail transports Japan etc, 10% of the above heavy vehicle traffic is assumed to divert to rail.

The result of calculation is shown in Table 6.4-3. Also, cases of 20% and 30% diversion are shown in the table as reference.

Table 6.4-3 Traffic Volume Diverted to Rail

Heavy Vehicle Traffic with Trip Length > 100 km (Year 2030)	Traffic Volume Diverted to Rail		
	Div. Rate: 10%	Div. Rate: 20%	Div. Rate: 30%
5,598 pcu	560 pcu	1,120 pcu	1,679

It should be noted that traffic volumes of 'semi trailers' and 'full trailers' actually observed at Station No. 5 and No. 7 are 194 vehicles/24 hr and 193 vehicles/24 hr, respectively (see Tables 5.1-5 and 5.1-6 in Chapter 5). With pcu factor of 3.0, these observed traffic volumes are converted to be around 580 pcu. Thus, 560 pcu, as calculated in Table 6.4-3, above is almost equivalent to the total traffic volume of semi trailers and full trailers observed in year 2011. Thus, the above calculation represents the situation where almost all the bulk and heavy cargo currently transported by semi trailers and full trailers divert to rail transport.

(ii) Influence of planned new road between Battambang and Siem Reap

The number of trips between the OD zones of Battambnag and southwards and Siem Reap and northwards is 2,187 pcu in year 2030. These trips can be assumed to divert to the new road.

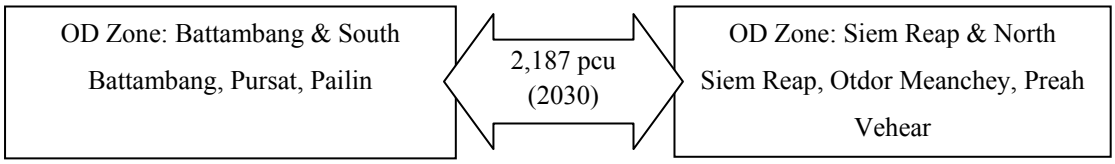


Figure 6.4-3 Trips Which can Divert to Planned Battambang – Siem Reap Raod

(iii) Total diversion traffic volume

From the above, the total of possible diversion traffic is calculated to be;

560 + 2,187 = 2,747 pcu.

The traffic volume on the North Section (Battambang – Sri Sophorn) in year 2030 is estimated at 25,540 pcu (see Table 6.4-1). Thus, the total diversion traffic volume is a little more than 10% of the traffic volume estimated in year 2030. Therefore, influence of the diversion to rail and new road does not give substantial influence to the overall plan of improvement of NR 5.

6.4.2 Peak Hour Traffic Volume and Congestion

Table 6.4-4 shows the traffic volumes in peak hour at the traffic counting stations. The degree of congestion expressed in the form of the ratio of traffic volume against traffic capacity of the road (v/c ratio or VCR). VCR of 0.85 is usually considered to be the allowable limit of congestion in road planning.

VCR in peak hour at Station No. 6 is anticipated to become 1.0 in year 2021. The location of station No.6 is within the urbanized area of Battambang City. Therefore, the traffic volume at station No.6 is considered to include the short trips within the city or around the city.

By year 2030, at all the counting stations except No. 2, No. 4, No. 5 and No. 9, VCRs exceed

1.0. Thus both the South Section and North Section need widening by that time.

Table 6.4-4 Peak Hour Traffic Volume and Congestion Degree

Sation No.	Peak Hour Volume (PCU)				Congestion Degree VCR				Lnk Capacity(hour)	No. of Lane
	2011	2016	2021	2030	2011	2016	2021	2030		
1	1103	1531	2146	2978	0.41	0.57	0.79	1.10	2700	1.5x2
2	948	1264	1726	2322	0.35	0.47	0.64	0.86	2700	1.5x2
3	781	1052	1448	1992	0.39	0.53	0.72	1.00	2000	2
4	565	750	1015	1397	0.28	0.37	0.51	0.70	2000	2
5	507	687	949	1327	0.19	0.25	0.35	0.49	2700	1.5x2
6	1276	1858	2712	3898	0.47	0.69	1.00	1.44	2700	1.5x2
7	772	1153	1710	2509	0.39	0.58	0.86	1.25	2000	2
8	821	1200	1729	2479	0.41	0.60	0.86	1.24	2000	2
9	711	1007	1408	1887	0.36	0.50	0.70	0.94	2000	2

It should be noted that **daily traffic volumes** at Stations No. 7 and 8 exceed, or approach, 20,000 PCU by year 2021 (see Table 6.4-1). 20,000 PCU is generally considered to be, or close to be, the capacity of an opposed 2-lane road. Thus, the traffic at these locations is anticipated to be congested. By year 2030, the daily traffic volume at stations No. 1, 6, 7 and 8 exceed, 25,000 PCU and widening of the North Section and the South Section will becomes absolutely necessary.

6.4.3 Traffic Volume on Bypass

One of the tasks included in the Scope of this Survey is to study the possibility of construction of bypasses around Kampong Chhnang, Battambang and Sri Sophorn. Table 6.4-5 shows the forecasted traffic volume on these bypasses.

Table 6.4-5 Future Traffic Volume on Bypass

Area	Section	2011	2016	2021	2030
Kampong Chhnang	Bypass	6,437	8,499	11,432	15,395
	Inner city	1,752	2,456	3,533	4,859
Battambang	Bypass	3,831	5,450	7,840	11,799
	Inner city	6,886	10,161	15,495	22,136
Sri Sophorn	Bypass	3,940	5,563	7,632	10,281
	Inner city	4,505	6,546	9,482	13,284

While the traffic volume on the bypass is almost three times of what goes into the city in Kampong Chhnang, the traffic volume going into the city of Battambang is much larger than that on the bypass. The larger traffic volume going into the city of Battambang may well be attributed to the fact that Battambang City is the core city of the region and attracts/generates traffic.