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**CHAPTER 7**  
***ECONOMIC EVALUATION OF THE PROJECT***

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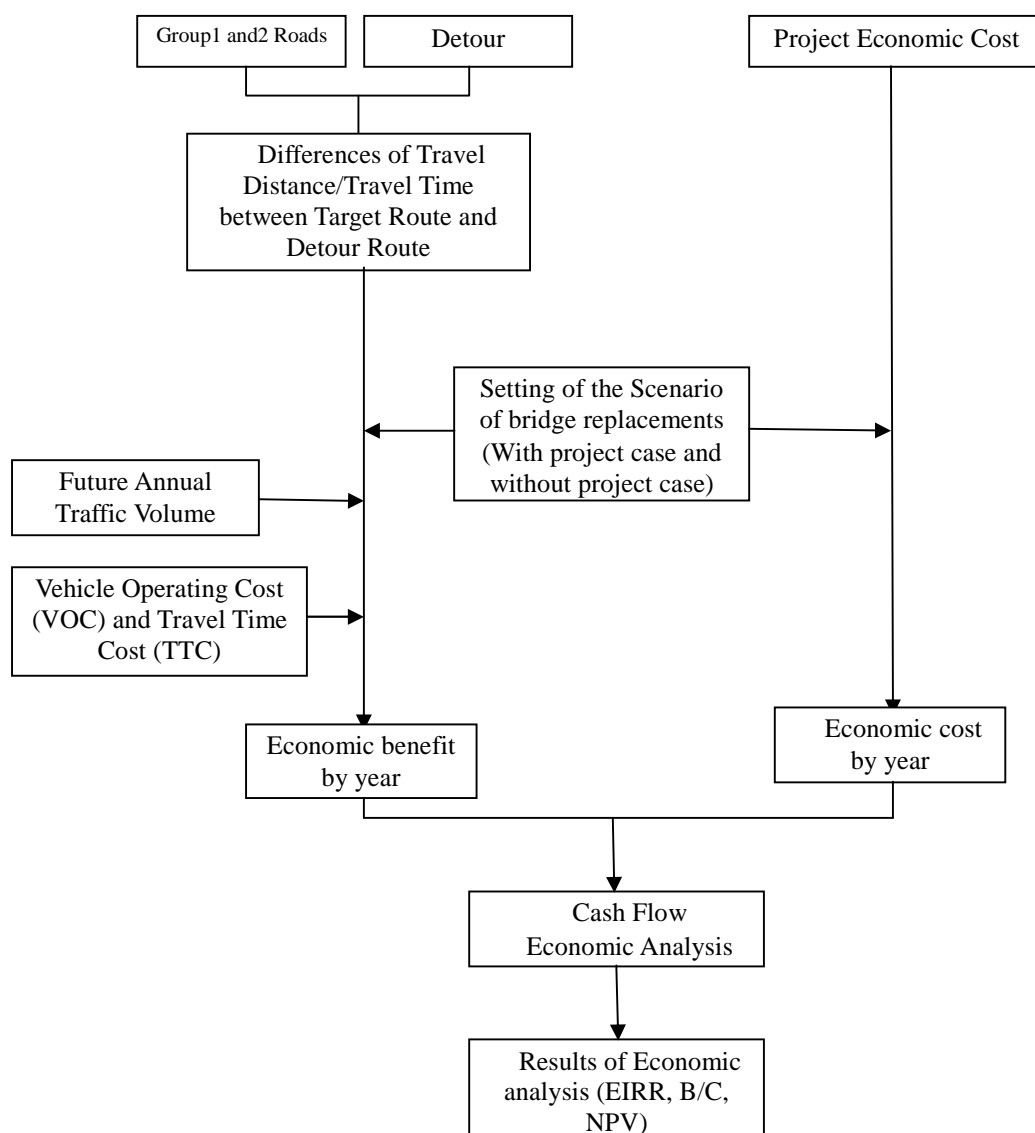
## 7. ECONOMIC EVALUATION OF THE PROJECT

### 7.1 Methodology

Economic analysis was carried out through economic cash flow analysis. The economic analysis is a comparative analysis between benefits and costs relative to the project.

Cost is the economic cost that includes construction cost and maintenance cost without subsidy or taxes. Benefit includes benefit of time saving and benefit of vehicle operating cost saving.

The figure below shows the flow of an economic evaluation,



**Figure 7-1 Procedure for Economic Analysis**

## 7.2 Assumptions for Economic Analysis

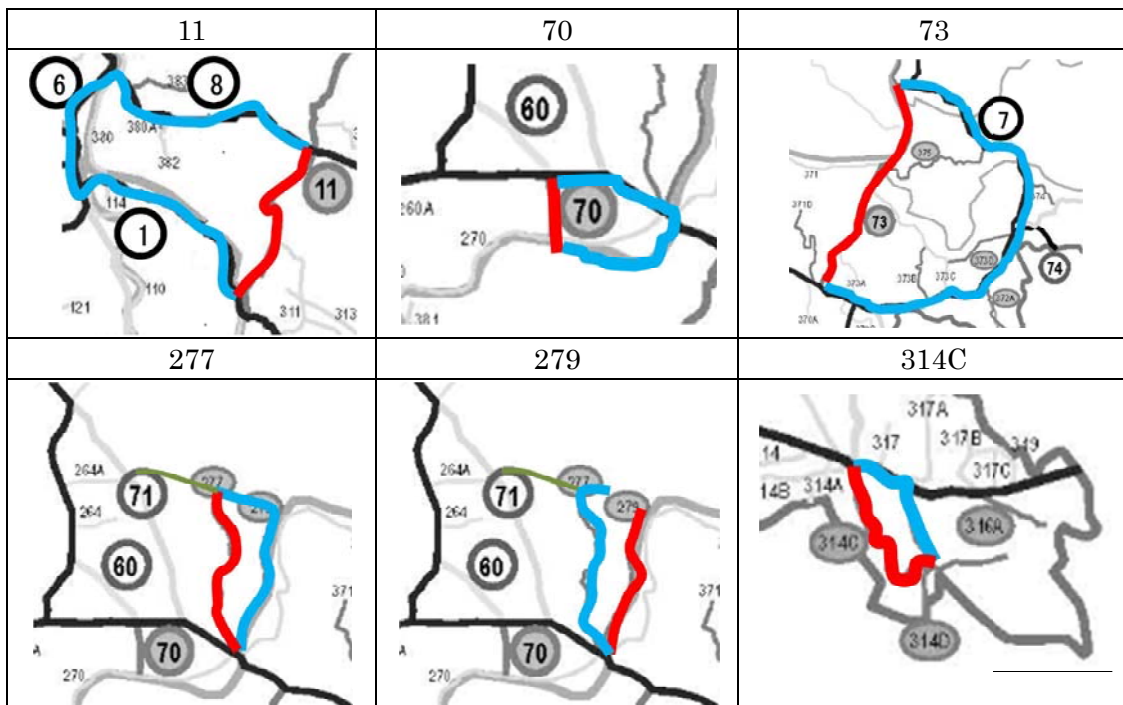
### (1) Roads of Group1 and Group2, and Detours for the Evaluation

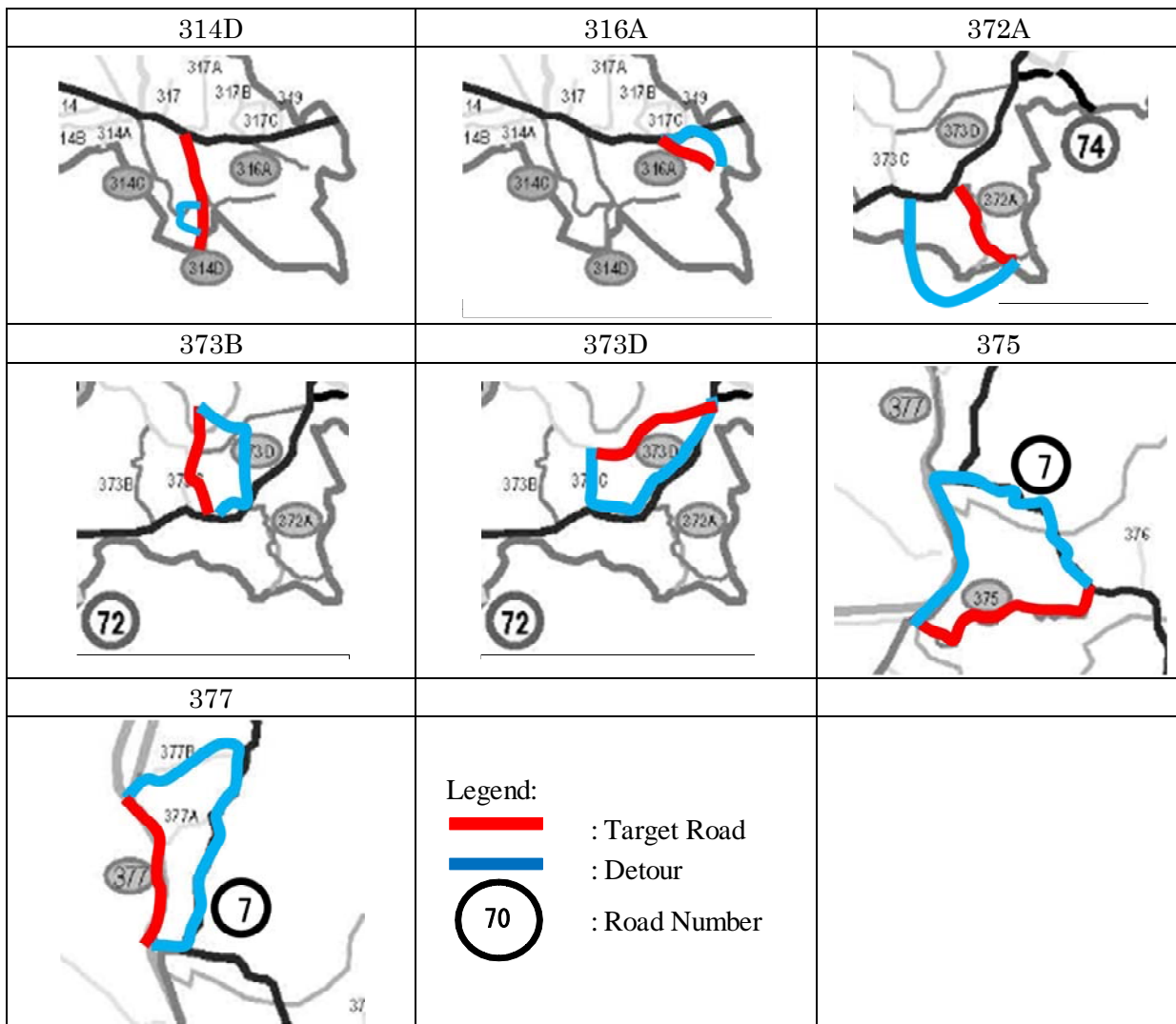
The economic analysis was carried out for 13 roads of Group 1 and 2 selected in Chapter 2.

**Table 7-1 13 Analysed Roads**

	Road Number
1	11
2	70
3	73
4	277
5	279
6	314C
7	314D
8	316A
9	372A
10	373B
11	373D
12	375
13	377

Detours of the roads of Group 1 and 2 are shown in the Figure 7-2.





**Figure 7-2 Detours for 13 Roads**

**(2) Difference of Travel Distance and Travel Time between Target Routes and Detours**

Travel speed surveys were carried out to obtain the travel time and travel speed of 13 roads and detour.

According to the results of the travel speed surveys, average travel speeds of unpaved roads and paved roads are different.

**Table 7-2 Average Travel Speed**

Classification	Surface condition	Average Travel Speed (km/hour)
2-digit roads	Unpaved	31
	Paved	56 - 68
3-digit roads	Unpaved	21-51
	Paved	41-51

Source: Study Team

Note: Unpaved road includes partly paved road.

Average travel speeds of some unpaved roads are lower than for paved roads. However, 2- and 3-digit roads have been improved rapidly in Cambodia in recent years. Therefore, the Study Team assumed that unpaved roads would be improved in the future, thus average travel speed of unpaved 2- and 3-digit roads would be improved. If the unpaved 2-digit roads average travel speed was less than 56 km/hour, it was assumed that 2-digit roads average travel speed was 55 km/hour for the analysis. Other 2-digit roads average speeds were assumed to be the same average speed as observed in the survey. If the unpaved 3-digit roads average speed was less than 41 km/hour, it is assumed that 3-digit roads average travel speed was 40 km/hour. On other 3-digit roads average speeds were assumed to be the same speed as observed in the survey.

Differences of travel distance and travel time between target routes and detours are calculated using the results of the travel speed survey. The differences are shown below.

Difference of Travel Distance (km) = Detour Length (km) - the Road Length (km)

Difference of Travel Time (hour) = Travel Time of Detour (hour) – Travel Time of the road(hour)

It was assumed the differences of distances and the times between the roads of Group1 and 2, and the detour will be the same in the future. The differences are used as the distance and time saving for the economic analysis.

Drivers usually select a shorter travel time route. If a driver selects the roads although the detour travel time is shorter, it must be because his destination is on the roads. Therefore, if time difference is negative, the route destination must be within the roads. Thus the destinations were assumed to be at the midpoint of the road for the analysis.

**Table 7-3 Difference of Travel Distance and Travel Time between Target Routes and Detours  
for Economic Analysis**

	<b>Road Number</b>	<b>Travel Distance Difference (km)</b>	<b>Travel Time Difference (hour)</b>
1	11	39.0	1.31
2	70*	33.5	0.69
3	73	82.6	1.25
4	277* **	27.0	0.67
5	279	18.9	0.65
6	314C* **	5.5	0.03
7	314D*	1.4	0.04
8	316A	3.7	0.04
9	372A	24.9	0.24
10	373B* **	22.3	0.19
11	373D*	21.7	0.15
12	375* **	50.0	0.51
13	377	50.4	0.55

Source: Study Team

Note:\*= Modified average travel speed.

\*\*=Destination was assumed to be at the midpoint of 13 roads.

**(3) Setting of the Scenario of Bridge Replacements (“With project case” and “Without project case”)**

1) Replacement Plan and Evaluation Period for NR11, NR70, NR73, PR279

a) With project case

First replacement start time: April 2014.

If two or more bridges are on the roads, each replacement will start one year after the previous bridge replacement started. Additional bridges replacements will not start at the same time.

Construction period: 26months

There is no impassable period.

b) Without project case

First time of bridge becoming impassable: November 2018

The route will become passable 14 months after it became impassable

First bridge replacement start time: November 2019.

If two or more bridges are on the roads, it is assumed that another bridge will become impassable every two years and not more than one bridge will be impassable at any given time.

Construction period: 26months

2) Replacement Plan and Evaluation Period for PR277, PR372A, PR373B, PR373d, PR375, PR377, PR314C, PR314D, PR316A

a) With project case

First replacement start time: April 2014.

If two or more bridges are on the roads, each replacement will start one year after the previous bridge replacement.

Construction period: 19months

There is no impassable period.

b) Without project case

First time of bridge becoming impassable: November 2018

The route will become passable 14 months after it first became impassable.

First bridge replacement start time: November 2019.

If two or more bridges are on the roads, it is assumed that another bridge will become impassable every two years and not more than one bridge will be impassable at any given time.

Construction period: 19months

Replacement Schedules of the “with project case” and “without project case” are shown below.



**Table 7-4 Project Implementation Schedule of “With Project Case” of NR11, NR70, NR73, PR279 for Economic Analysis**

	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Temporary Bridge for New Bridge (1)	■							
Construction of New Bridge (1)	■	■	■					
Construction of Temporary Bridge for New Bridge (2)		■						
Construction of New Bridge (2)		■	■	■				
Construction of Temporary Bridge for New Bridge (3)			■					
Construction of New Bridge (3)			■	■	■			
Construction of Temporary Bridge for New Bridge (4)				■				
Construction of New Bridge (4)				■	■	■		
Construction of Temporary Bridge for New Bridge (5)					■			
Construction of New Bridge (5)					■	■	■	
Construction of Temporary Bridge for New Bridge (6)						■		
Construction of New Bridge (6)						■	■	■
Traffic	-	-	-	-	-	-	-	-

Source: Study Team

Note: Traffic, “-“=Passable, “x”=Impassable

**Table 7-5 Project Implementation Schedule of “Without Project Case” of NR11, NR70, NR73, PR279 for Economic Analysis**

	2018	2019	2020	2021	2022	2023	2024
Preparation Period (1)							
Construction of Temporary Bridge for New Bridge (1)							
Construction of New Bridge (1)							
Preparation Period (2)							
Construction of Temporary Bridge for New Bridge (2)							
Construction of New Bridge (2)							
Preparation Period (3)							
Construction of Temporary Bridge for New Bridge (3)							
Construction of New Bridge (3)							
Preparation Period (4)							
Construction of Temporary Bridge for New Bridge (4)							
Construction of New Bridge (4)							
Preparation Period (5)							
Construction of Temporary Bridge for New Bridge (5)							
Construction of New Bridge (5)							
Preparation Period (6)							
Construction of Temporary Bridge for New Bridge (6)							
Construction of New Bridge (6)							
Traffic	-----XX	XXXXXXXXXXXXXX	-----XX	XXXXXXXXXXXXXX	-----XX	XXXXXXXXXXXXXX	-----XX
	2025	2026	2027	2028	2029	2030	2031
Preparation Period (1)							
Construction of Temporary Bridge for New Bridge (1)							
Construction of New Bridge (1)							
Preparation Period (2)							
Construction of Temporary Bridge for New Bridge (2)							
Construction of New Bridge (2)							
Preparation Period (3)							
Construction of Temporary Bridge for New Bridge (3)							
Construction of New Bridge (3)							
Preparation Period (4)							
Construction of Temporary Bridge for New Bridge (4)							
Construction of New Bridge (4)							
Preparation Period (5)							
Construction of Temporary Bridge for New Bridge (5)							
Construction of New Bridge (5)							
Preparation Period (6)							
Construction of Temporary Bridge for New Bridge (6)							
Construction of New Bridge (6)							
Traffic	XXXXXXXXXXXXXX	-----XX	XXXXXXXXXXXXXX	-----XX	XXXXXXXXXXXXXX	-----XX	-----XX

Source: Study Team

Note: Traffic, “-“=Passable, “x”=Impassable

**Table 7-6 Project Implementation Schedule of “With Project Case” of PR277, PR372A, PR373B, PR373d, PR375, PR377, PR314C, PR314D,PR316A for Economic Analysis**

	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Temporary Bridge for New Bridge (1)	■							
Construction of New Bridge (1)	■	■	■					
Construction of Temporary Bridge for New Bridge (2)		■						
Construction of New Bridge (2)		■	■	■				
Construction of Temporary Bridge for New Bridge (3)			■					
Construction of New Bridge (3)			■	■	■			
Construction of Temporary Bridge for New Bridge (4)				■				
Construction of New Bridge (4)				■	■	■		
Construction of Temporary Bridge for New Bridge (5)					■			
Construction of New Bridge (5)					■	■	■	
Construction of Temporary Bridge for New Bridge (6)						■		
Construction of New Bridge (6)						■	■	■
Construction of Temporary Bridge for New Bridge (7)							■	
Construction of New Bridge (7)							■	■
Construction of Temporary Bridge for New Bridge (8)								■
Construction of New Bridge (8)								■
Construction of Temporary Bridge for New Bridge (9)								
Construction of New Bridge (9)								
Construction of Temporary Bridge for New Bridge (10)								
Construction of New Bridge (10)								
Construction of Temporary Bridge for New Bridge (11)								
Construction of New Bridge (11)								
Construction of Temporary Bridge for New Bridge (12)								
Construction of New Bridge (12)								
Traffic	----	----	----	----	----	----	----	----
	2022	2023	2024	2025	2026			
Construction of Temporary Bridge for New Bridge (1)								
Construction of New Bridge (1)								
Construction of Temporary Bridge for New Bridge (2)								
Construction of New Bridge (2)								
Construction of Temporary Bridge for New Bridge (3)								
Construction of New Bridge (3)								
Construction of Temporary Bridge for New Bridge (4)								
Construction of New Bridge (4)								
Construction of Temporary Bridge for New Bridge (5)								
Construction of New Bridge (5)								
Construction of Temporary Bridge for New Bridge (6)								
Construction of New Bridge (6)								
Construction of Temporary Bridge for New Bridge (7)								
Construction of New Bridge (7)								
Construction of Temporary Bridge for New Bridge (8)	■							
Construction of New Bridge (8)	■							
Construction of Temporary Bridge for New Bridge (9)	■	■						
Construction of New Bridge (9)	■	■	■					
Construction of Temporary Bridge for New Bridge (10)		■						
Construction of New Bridge (10)		■	■	■				
Construction of Temporary Bridge for New Bridge (11)			■					
Construction of New Bridge (11)			■	■	■			
Construction of Temporary Bridge for New Bridge (12)				■				
Construction of New Bridge (12)				■	■	■		
Traffic	----	----	----	----	----	----	----	----

Source: Study Team  
 Note: Traffic, “-“=Passable, “x”=Impassable



**(4) Evaluation Period and Expansion Factor from Daily Traffic to Annual Traffic Volume**

The evaluation period is assumed to be 30 years from 2018 to 2047 as the service life of the projects. The expansion factor from daily traffic to annual traffic volume is assumed to be 340 days per year considering weekly variation of the traffic volume.

**(5) Discount Rate**

Twelve percent is assumed as the discount rate in Cambodia.

**(6) Future Traffic Volume**

Traffic volume is basic data for the estimation of the benefit of the project. The traffic demand forecasts for the roads have been carried out with a simplified method considering the traffic volume and the growth ratios of the number of registered vehicles, because most of the roads do not have past traffic volume data. Future traffic annual volumes were estimated by the formula below.

$$\text{Future Annual Traffic Volume} = \text{Daily Traffic Volume of Previous Year} \times \text{Annual Growth Rate of Registered Vehicles} \times 340 \text{ (days)}$$

1) The growth rate of registered vehicles by vehicle type

The JICA study report, the "Preparatory Survey for the National Road No.5 Rehabilitation Project in the Kingdom of Cambodia, 2012" (hereinafter referred to as the NR5 report), estimated growth rates of registered vehicles by vehicle type. These rates of the "Medium Growth Scenario" are accepted for estimation of the future traffic volumes.

**Table 7-8 Annual Growth Rate of Vehicle Registrations**

<b>Year</b>	<b>Motorcycle</b>	<b>Light Vehicle</b>	<b>Heavy Vehicle</b>
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%
2031-2040*	0.8-0.4%	3.5%	3.5%
2041-2047*	0.3-0.2%	3%	3%

Source: Preparatory Survey for National Road No.5 Rehabilitation Project in the Kingdom of Cambodia, JICA, 2012

Note: \* = the Study Team set growth rate

2) Current and future daily traffic volumes

Daily traffic volumes of each target route are shown below. Heavy vehicle traffic volume includes buses and trucks. Future bus traffic volume was calculated using the current bus traffic ratio to heavy vehicle traffic.

**Table 7-9 Current and Future Daily Traffic Volume by Vehicle Type**

Unit: Vehicle/day

	11				70				73			
	MC	LV	HV		MC	LV	HV		MC	LV	HV	
			Bus	Truck			Bus	Truck			Bus	Truck
2012	5,260	645	55	689	4,415	328	5	234	3,200	1,115	55	361
2014	6,480	767	65	818	5,440	390	6	278	3,942	1,325	65	430
2020	9,271	1,098	94	1,172	7,782	559	8	398	5,640	1,897	94	616
2026	10,544	1,473	125	1,571	8,850	749	11	532	6,414	2,543	126	825
2030	10,972	1,723	147	1,837	9,209	876	13	623	6,674	2,975	147	966
2040	11,669	2,430	207	2,590	9,793	1,236	19	877	7,098	4,196	208	1,362
2047	11,822	2,989	254	3,185	9,921	1,520	23	1,079	7,189	5,162	255	1,676
	277				279				314C			
	MC	LV	HV		MC	LV	HV		MC	LV	HV	
			Bus	Truck			Bus	Truck			Bus	Truck
2012	1,018	6	0	28	6,228	538	6	144	1,872	58	0	30
2014	1,254	8	0	33	7,673	639	7	171	2,307	69	0	36
2020	1,794	14	0	46	10,978	916	10	244	3,301	99	0	52
2026	2,040	20	0	62	12,484	1,229	14	326	3,754	132	0	70
2030	2,123	24	0	73	12,991	1,437	16	382	3,907	154	0	82
2040	2,257	34	0	104	13,816	2,028	22	539	4,155	217	0	116
2047	2,287	41	0	127	13,997	2,497	28	662	4,208	268	0	143
	314D				316A				372A			
	MC	LV	HV		MC	LV	HV		MC	LV	HV	
			Bus	Truck			Bus	Truck			Bus	Truck
2012	1,039	108	0	103	1,950	114	0	106	914	35	0	12
2014	1,280	129	0	122	2,402	135	0	126	1,126	42	0	14
2020	1,831	184	0	175	3,436	193	0	181	1,611	60	0	20
2026	2,082	247	0	235	3,908	259	0	244	1,832	80	0	26
2030	2,166	289	0	275	4,066	303	0	286	1,907	93	0	30
2040	2,301	407	0	388	4,323	428	0	403	2,029	130	0	40
2047	2,331	501	0	478	4,379	526	0	495	2,055	160	0	47
	373B				373D				375			
	MC	LV	HV		MC	LV	HV		MC	LV	HV	
			Bus	Truck			Bus	Truck			Bus	Truck
2012	962	160	0	69	1,590	381	0	68	1,088	121	0	41
2014	1,185	190	0	82	1,959	453	0	81	1,341	144	0	49
2020	1,696	272	0	118	2,803	650	0	117	1,919	206	0	69
2026	1,929	365	0	159	3,188	872	0	156	2,183	276	0	92
2030	2,007	427	0	186	3,318	1,020	0	182	2,271	322	0	108
2040	2,132	602	0	263	3,530	1,439	0	257	2,415	453	0	152
2047	2,158	741	0	323	3,578	1,770	0	316	2,445	557	0	187
	377											
	MC	LV	HV									
			Bus	Truck								
2012	1,590	381	0	68								
2014	1,959	453	0	81								
2020	2,803	650	0	117								
2026	3,188	872	0	156								
2030	3,318	1,020	0	182								
2040	3,530	1,439	0	257								
2047	3,578	1,770	0	316								

Source: Study Team

### 7.3 Economic Cost Estimation

Economic costs of construction are shown below. Maintenance costs of a new bridge are low, thus maintenance costs are overlooked for the analysis.

- a) Bridge construction cost on NR11, NR70, NR73 and PR279  
USD 1,576,000/Bridge
- b) Bridge construction cost on PR277, PR372A, PR373B, PR373D, PR375, PR377, PR314C, PR314D and PR316A  
USD 583,000/Bridge

### 7.4 Benefit Estimation

Travel distance cost saving and travel time cost saving were considered as benefits for the economic analysis. Vehicle Operating Costs (VOC) and Travel Time Costs (TTC) were estimated based on the data from the NR5 report.

#### (1) Vehicle Operating Cost (VOC)

VOC of the NR5 report was modified using inflation ratio (3.61%) in 2012.

**Table 7-10 Vehicle Operating Cost By Vehicle Type**

Unit: USD/1,000km			
Motorcycle	Light Vehicle	Heavy Vehicle	
		Bus	Truck
38.6	185.0	298.7	329.1

Source: Study team

#### (2) Travel Time Cost (TTC)

The data from the NR5 report is adapted for the analysis of TTC in the project. TTC in the NR5 report was estimated by the Average Wage Approach method. The wages rates of vehicle occupants were estimated to reflect the time value of the occupants in different vehicles.

**Table 7-11 Forecast of Time Value by Vehicle Type**

Year	Motorcycle	Light Vehicle	Heavy Vehicle	
			Bus	Truck
2012	0.55	7.75	6.25	1.24
2016	0.66	9.43	7.6	1.51
2021	0.84	11.91	9.6	1.9
2030	1.23	17.47	14.08	2.79

Source: "Preparatory Survey for National Road No.5 Rehabilitation Project , 2012"

Note: Figures of 2012 were estimated by the Study Team

### **(3) Benefit Estimation**

Benefit will be calculated by the reduction of travel distance and travel time as an outcome of a Project in general, however the maintenance project including bridge replacement will not create any reduction of travel distance or travel time. On the other hand, all the traffic on a road will be stopped and forced to use a detour when a bridge on the road is closed due to significant damage. An unbearable loss from increasing travel distance and travel time will be incurred by using a detour when the road is closed. Loss arising from increase of travel distance and travel time by closing the bridges is shown in Table 7-12.

As shown in the Table 7-12, the loss by closing the bridges is unbearable compared with the replacement cost, so that the projects to reopen the roads are absolutely essential, therefore, the road authority shall keep the bridge open. For this reason, the do nothing case is not taken into consideration in the Study and benefit of the project is considered to be the difference between preventive maintenance and breakdown maintenance. Definitions of the breakdown maintenance and preventive maintenance are as follows:

1) Breakdown maintenance :

A bridge is not replaced nor maintained until the bridge is closed to traffic. The road will be closed until a detour alongside of the existing bridge can be established. The following cases are examined;

Case1 : Road will be open to traffic 14months after the bridge closure.

Case2: Road will be open to traffic 3 months after the bridge closure.

2) Preventive maintenance

A bridge is replaced before the bridge is closed to traffic.

**Table 7-12 Construction Cost, and Loss (Benefit)\* Occurred by Closing of Bridges**

<b>Road No.</b>	<b>Cost (1,000 USD)</b>	<b>Loss (Benefit) (1,000USD)</b>	<b>B/C</b>
11	2,168	147,921	68.2
70	2,168	54,366	25.1
73	5,274	203,656	38.6
277	830	6,434	7.8
279	1,145	55,123	48.1
314C	439	1,717	3.9
314D	439	807	1.8
316A	439	1,975	4.5
372A	1,771	4,369	2.5
373B	439	8,327	19
373D	2,775	14,087	5.1
375	1,180	16,755	14.2
377	3,043	38,299	12.6

Source: Study Team



Travel distance saving and travel time saving are estimated using the formulas below.

Heavy Vehicle Traffic volume includes Bus and Truck. Future Bus traffic volume was calculated using the current bus traffic ratio to heavy vehicle traffic.

Travel distance saving = (Travel length of without project case - Travel length of with project case) x VOC x Traffic volume

Travel time saving = (Travel time of without project case - Travel time of with project case) x VOC x Traffic volume

## 7.5 Economic Analysis

### (1) Base case results

The economic indicators shown below were calculated by economic analysis

- 1) Economic Internal Rate of Return (EIRR)
- 2) Benefit – Cost Ratio (B/C Ratio)
- 3) Net Present Value (NPV)

Results of the economic analysis are shown below. EIRR of NR11, NR70, NR73, PR277, PR279, PR373B, PR373D, PR375 and PR377 are over 12% (discount rate), thus they are at a feasible level.

The cash flows for the economic analysis of the project are shown in Table 7-14 to Table 7-26. The cash flows are based on the annual user’s benefit and project cost estimations.

**Table 7-13 Results of Economic Analysis**

	Road Number	EIRR	B/C	NPV (1,000 USD)
1	11	88.2%	10.1	19,695
2	70	53.0%	4.0	6,602
3	73	94.6%	14.3	70,018
4	277	19.2%	1.3	289
5	279	54.5%	3.8	3,163
6	314C	Negative	0.4	-264
7	314D	Negative	0.1	-374
8	316A	Negative	0.4	-257
9	372A	10.4%	0.9	-144
10	373B	26.1%	1.7	298
11	373D	31.2%	2.7	4,683
12	375	42.6%	3.4	2,815
13	377	61.0%	7.2	18,915

Source: Study Team

**Table 7-14 Economic Evaluation of NR11**

Unit: USD

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	545,538	0	0	0	-545,538	434,900	0	-434,900
2015	1,272,923	0	0	0	-1,272,923	906,042	0	-906,042
2016	1,030,462	0	0	0	-1,030,462	654,877	0	-654,877
2017	303,077	0	0	0	-303,077	171,974	0	-171,974
2018	0	1,944,965	1,392,903	3,337,868	3,337,868	0	1,691,068	1,691,068
2019	0	12,285,060	9,230,517	21,515,577	21,515,577	0	9,732,554	9,732,554
2020	0	2,155,319	1,699,164	3,854,483	3,854,483	0	1,556,761	1,556,761
2021	0	13,482,645	11,149,738	24,632,384	24,632,384	0	8,882,685	8,882,685

Source: Study Team

**Table 7-15 Economic Evaluation of NR70**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	545,538	0	0	0	-545,538	434,900	0	-434,900
2015	1,272,923	0	0	0	-1,272,923	906,042	0	-906,042
2016	1,030,462	0	0	0	-1,030,462	654,877	0	-654,877
2017	303,077	0	0	0	-303,077	171,974	0	-171,974
2018	0	927,511	431,125	1,358,636	1,358,636	0	688,327	688,327
2019	0	5,837,536	2,849,102	8,686,638	8,686,638	0	3,929,394	3,929,394
2020	0	1,020,469	523,101	1,543,570	1,543,570	0	623,422	623,422
2021	0	6,359,012	3,425,739	9,784,752	9,784,752	0	3,528,480	3,528,480

Source: Study Team

**Table 7-16 Economic Evaluation of NR73**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	545,538	0	0	0	-545,538	434,900	0	-434,900
2015	1,272,923	0	0	0	-1,272,923	906,042	0	-906,042
2016	1,576,000	0	0	0	-1,576,000	1,001,576	0	-1,001,576
2017	1,576,000	0	0	0	-1,576,000	894,265	0	-894,265
2018	1,576,000	3,367,676	1,353,316	4,720,992	3,144,992	798,451	2,391,802	1,593,351
2019	1,576,000	21,304,722	9,016,515	30,321,237	28,745,237	712,902	13,715,788	13,002,886
2020	1,030,462	3,743,623	1,668,467	5,412,090	4,381,628	416,186	2,185,852	1,769,666
2021	303,077	23,467,325	11,015,478	34,482,803	34,179,726	109,293	12,434,845	12,325,552
2022	0	4,075,103	2,011,855	6,086,957	6,086,957	0	1,959,837	1,959,837
2023	0	25,481,631	13,227,086	38,708,717	38,708,717	0	11,127,831	11,127,831
2024	0	4,426,548	2,415,226	6,841,774	6,841,774	0	1,756,113	1,756,113
2025	0	27,682,729	15,876,379	43,559,108	43,559,108	0	9,982,623	9,982,623
2026	0	4,809,849	2,899,007	7,708,856	7,708,856	0	1,577,385	1,577,385
2027	0	29,805,582	18,877,921	48,683,503	48,683,503	0	8,894,294	8,894,294
2028	0	5,132,071	3,414,571	8,546,642	8,546,642	0	1,394,142	1,394,142
2029	0	31,809,304	22,230,817	54,040,122	54,040,122	0	7,870,638	7,870,638

Source: Study Team

**Table 7-17 Economic Evaluation of PR277**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	583,000	0	0	0	-583,000	414,968	0	-414,968
2016	306,842	0	0	0	-306,842	195,004	0	-195,004
2017	0	0	0	0	0	0	0	0
2018	0	122,137	53,075	175,212	175,212	0	88,768	88,768
2019	0	763,980	348,831	1,112,811	1,112,811	0	503,379	503,379
2020	0	133,204	63,731	196,935	196,935	0	79,539	79,539
2021	0	826,120	415,090	1,241,210	1,241,210	0	447,593	447,593

Source: Study Team

**Table 7-18 Economic Evaluation of PR279**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	545,538	0	0	0	-545,538	434,900	0	-434,900
2015	727,385	0	0	0	-727,385	517,738	0	-517,738
2016	303,077	0	0	0	-303,077	192,611	0	-192,611
2017	0	0	0	0	0	0	0	0
2018	0	660,999	598,524	1,259,523	1,259,523	0	638,113	638,113
2019	0	4,154,498	3,958,204	8,112,702	8,112,702	0	3,669,774	3,669,774

Source: Study Team

**Table 7-19 Economic Evaluation of PR314C**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	306,842	0	0	0	-306,842	218,404	0	-218,404
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	46,554	5,449	52,004	52,004	0	26,347	26,347
2019	0	291,719	35,851	327,570	327,570	0	148,176	148,176

Source: Study Team

**Table 7-20 Economic Evaluation of PR314D**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	306,842	0	0	0	-306,842	218,404	0	-218,404
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	11,671	7,223	18,894	18,894	0	9,572	9,572
2019	0	73,569	47,828	121,397	121,397	0	54,914	54,914

Source: Study Team

**Table 7-21 Economic Evaluation of PR316A**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	306,842	0	0	0	-306,842	218,404	0	-218,404
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	43,525	10,305	53,831	53,831	0	27,272	27,272
2019	0	273,795	67,997	341,792	341,792	0	154,609	154,609

Source: Study Team

**Table 7-22 Economic Evaluation of PR372A**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	583,000	0	0	0	-583,000	414,968	0	-414,968
2016	583,000	0	0	0	-583,000	370,507	0	-370,507
2017	583,000	0	0	0	-583,000	330,810	0	-330,810
2018	583,000	103,654	22,727	126,381	-456,619	295,366	64,028	-231,337
2019	306,842	649,038	149,555	798,593	491,751	138,800	361,243	222,443
2020	0	112,802	27,306	140,108	140,108	0	56,587	56,587
2021	0	700,000	178,197	878,197	878,197	0	316,687	316,687
2022	0	119,714	31,915	151,628	151,628	0	48,820	48,820
2023	0	736,893	205,671	942,564	942,564	0	270,965	270,965
2024	0	125,972	36,800	162,772	162,772	0	41,780	41,780
2025	0	776,335	238,013	1,014,347	1,014,347	0	232,462	232,462
2026	0	132,861	42,731	175,592	175,592	0	35,930	35,930
2027	0	810,541	273,059	1,083,600	1,083,600	0	197,970	197,970

Source: Study Team

**Table 7-23 Economic Evaluation of PR373B**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	306,842	0	0	0	-306,842	218,404	0	-218,404
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0
2018	0	176,831	40,612	217,443	217,443	0	110,163	110,163
2019	0	1,115,462	269,540	1,385,002	1,385,002	0	626,505	626,505

Source: Study Team

**Table 7-24 Economic Evaluation of PR 373D**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	583,000	0	0	0	-583,000	414,968	0	-414,968
2016	583,000	0	0	0	-583,000	370,507	0	-370,507
2017	583,000	0	0	0	-583,000	330,810	0	-330,810
2018	583,000	296,739	68,336	365,075	-217,925	295,366	184,958	-110,407
2019	583,000	1,872,444	453,703	2,326,147	1,743,147	263,720	1,052,231	788,511
2020	583,000	328,458	83,676	412,135	-170,865	235,464	166,454	-69,010
2021	583,000	2,052,959	549,851	2,602,811	2,019,811	210,236	938,600	728,364
2022	583,000	355,081	99,748	454,829	-128,171	187,710	146,443	-41,268
2023	583,000	2,211,027	651,683	2,862,710	2,279,710	167,599	822,961	655,362
2024	306,842	382,835	118,319	501,154	194,312	78,759	128,634	49,875
2025	0	2,386,013	773,462	3,159,476	3,159,476	0	724,070	724,070
2026	0	413,053	140,468	553,520	553,520	0	113,261	113,261
2027	0	2,549,793	909,388	3,459,181	3,459,181	0	631,979	631,979
2028	0	437,106	163,498	600,604	600,604	0	97,971	97,971
2029	0	2,700,923	1,058,995	3,759,918	3,759,918	0	547,611	547,611
2030	0	463,429	190,471	653,900	653,900	0	85,033	85,033
2031	0	2,853,703	1,271,544	4,125,247	4,125,247	0	478,969	478,969
2032	0	488,152	235,714	723,866	723,866	0	75,041	75,041
2033	0	3,004,634	1,572,575	4,577,209	4,577,209	0	423,665	423,665
2034	0	513,848	291,588	805,436	805,436	0	66,563	66,563
2035	0	3,162,046	1,945,724	5,107,770	5,107,770	0	376,892	376,892
2036	0	540,800	360,618	901,418	901,418	0	59,387	59,387
2037	0	3,329,145	2,406,688	5,735,833	5,735,833	0	337,401	337,401

Source: StudyTeam

**Table 7-25 Economic Evaluation of PR 375**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	583,000	0	0	0	-583,000	414,968	0	-414,968
2016	583,000	0	0	0	-583,000	370,507	0	-370,507
2017	306,842	0	0	0	-306,842	174,110	0	-174,110
2018	0	347,077	94,937	442,014	442,014	0	223,938	223,938
2019	0	2,186,090	628,482	2,814,572	2,814,572	0	1,273,169	1,273,169
2020	0	382,473	115,681	498,153	498,153	0	201,196	201,196
2021	0	2,381,184	757,765	3,138,949	3,138,949	0	1,131,936	1,131,936
2022	0	410,741	136,970	547,711	547,711	0	176,348	176,348
2023	0	2,547,708	890,013	3,437,722	3,437,722	0	988,263	988,263

Source: Study Team

**Table 7-26 Economic Evaluation of PR 377**

Year	Total Cost	VOC Saving	Time Cost Saving	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
						Discounted Cost	Discounted Benefit	Net Benefit
2014	276,158	0	0	0	-276,158	220,151	0	-220,151
2015	583,000	0	0	0	-583,000	414,968	0	-414,968
2016	583,000	0	0	0	-583,000	370,507	0	-370,507
2017	583,000	0	0	0	-583,000	330,810	0	-330,810
2018	583,000	689,201	250,565	939,766	356,766	295,366	476,115	180,749
2019	583,000	4,348,902	1,663,576	6,012,479	5,429,479	263,720	2,719,740	2,456,020
2020	583,000	762,871	306,813	1,069,685	486,685	235,464	432,028	196,564
2021	583,000	4,768,164	2,016,122	6,784,286	6,201,286	210,236	2,446,481	2,236,246
2022	583,000	824,704	365,743	1,190,447	607,447	187,710	383,292	195,582
2023	583,000	5,135,288	2,389,506	7,524,794	6,941,794	167,599	2,163,199	1,995,600
2024	583,000	889,166	433,835	1,323,001	740,001	149,642	339,581	189,940
2025	583,000	5,541,708	2,836,028	8,377,736	7,794,736	133,609	1,919,961	1,786,352
2026	306,842	959,348	515,048	1,474,395	1,167,553	62,786	301,691	238,905
2027	0	5,922,100	3,334,423	9,256,523	9,256,523	0	1,691,132	1,691,132
2028	0	1,015,214	599,492	1,614,706	1,614,706	0	263,393	263,393
2029	0	6,273,111	3,882,983	10,156,094	10,156,094	0	1,479,178	1,479,178
2030	0	1,076,352	698,393	1,774,744	1,774,744	0	230,787	230,787
2031	0	6,627,955	4,662,329	11,290,284	11,290,284	0	1,310,878	1,310,878
2032	0	1,133,773	864,284	1,998,057	1,998,057	0	207,132	207,132
2033	0	6,978,505	5,766,107	12,744,612	12,744,612	0	1,179,636	1,179,636
2034	0	1,193,452	1,069,156	2,262,609	2,262,609	0	186,988	186,988
2035	0	7,344,107	7,134,321	14,478,428	14,478,428	0	1,068,334	1,068,334
2036	0	1,256,052	1,322,266	2,578,318	2,578,318	0	169,865	169,865
2037	0	7,732,208	8,824,524	16,556,732	16,556,732	0	973,922	973,922
2038	0	1,321,879	1,635,511	2,957,390	2,957,390	0	155,325	155,325
2039	0	8,134,698	10,914,740	19,049,438	19,049,438	0	893,296	893,296
2040	0	1,391,684	2,024,138	3,415,821	3,415,821	0	143,018	143,018
2041	0	8,538,855	13,453,262	21,992,117	21,992,117	0	822,137	822,137

Source: Study Team

### (7) Sensitivity Analysis

Sensitivity analysis is used to demonstrate how the economic analysis results change with variations in the input data and assumptions, particularly the primary economic indicator of EIRR. The sensitivity analysis was conducted for a decrease in benefit of 10% and an increase in cost of 10% and for both cases. The results are summarized in the following table. EIRRs in NR11, NR70, NR73, PR277, PR279, PR373B, PR373D, PR375 and PR377 remains over 12%.

**Table 7-27 Summary of Sensitivity Results**

	Road Number	Base Case	Decrease in Benefit of 10%	Increase in Cost of 10%	Decrease in Benefit of 10% & Increase in Cost of 10%
1	11	88.2%	83.7%	84.2%	79.8%
2	70	53.0%	49.4%	49.8%	46.2%
3	73	94.6%	89.8%	90.2%	85.5%
4	277	19.2%	16.6%	16.8%	14.3%
5	279	54.5%	50.6%	51.0%	47.2%
6	314C	Negative	Negative	Negative	Negative
7	314D	Negative	Negative	Negative	Negative

	Road Number	Base Case	Decrease in Benefit of 10%	Increase in Cost of 10%	Decrease in Benefit of 10% & Increase in Cost of 10%
8	316A	Negative	Negative	Negative	Negative
9	372A	10.4%	8.5%	8.7%	6.9%
10	373B	26.1%	23.1%	23.4%	20.5%
11	373D	31.2%	28.6%	28.8%	26.4%
12	375	42.6%	39.6%	39.9%	36.9%
13	377	61.0%	57.1%	57.8%	54.0%

Source: Study Team

**(8) Another “Without Project Case”**

The impassable period of the “Break down maintenance case” was 14 months per bridge taking into account an the administration procedure, design period and construction of detour. However, there is some other measure to reduce the impassable time for instance, the government prepare special fund for urgent repair of the bridge. With such case, the impassable time will be reduced to three months as in case-2.

Results of the economic analysis for case-2 are shown in the following table. EIRR in NR11, NR73 and PR377 is over 12% (discount rate), thus they still keep feasible level.

**Table 7-28 Results of Economic Analysis using Basic “with project case” and another “without project case”**

	Road Number	EIRR	B/C	NPV (1,000 USD)
1	11	36.8%	2.21	2,631
2	70	8.9%	0.89	-235
3	73	41.5%	3.15	11,327
4	277	Negative	0.30	-583
5	279	6.0%	0.82	-201
6	314C	Negative	0.09	-400
7	314D	Negative	0.03	-424
8	316A	Negative	0.09	-398
9	372A	Negative	0.20	-1,409
10	373B	Negative	0.37	-276
11	373D	4.9%	0.60	-1,124
12	375	5.5%	0.75	-295
13	377	19.7%	1.59	1,802

Source: Study Team

**(9) Conclusion of the Economic Analysis**

The replacement of bridges on NR11, NR70, NR73, PR277, PR279, PR373B, PR373D, PR375 and PR377 in case-1 is considered as feasible based on the economic analysis. Especially, NR11, NR73 and PR377 are still feasible level, even if the impassable period is reduced to three months as in case-2.





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**CHAPTER 8**

***STUDY ON THE INFORMATION SYSTEM***

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## 8. STUDY ON THE INFORMATION SYSTEM

### 8.1 Existing condition of Bridge Maintenance

A periodical bridge inspection per two years, a visual inspection per month and ad hoc inspection based on the information from local people or road users are carried out by the DPWT. The budget for bridge repair is prepared by the MEF through the MPWT. The practical bridge repairs are carried out by RID Bridge Unit in the DPWT. Relevant organization in the Cambodia for bridge maintenance and their functions are shown in Figure 8-1.

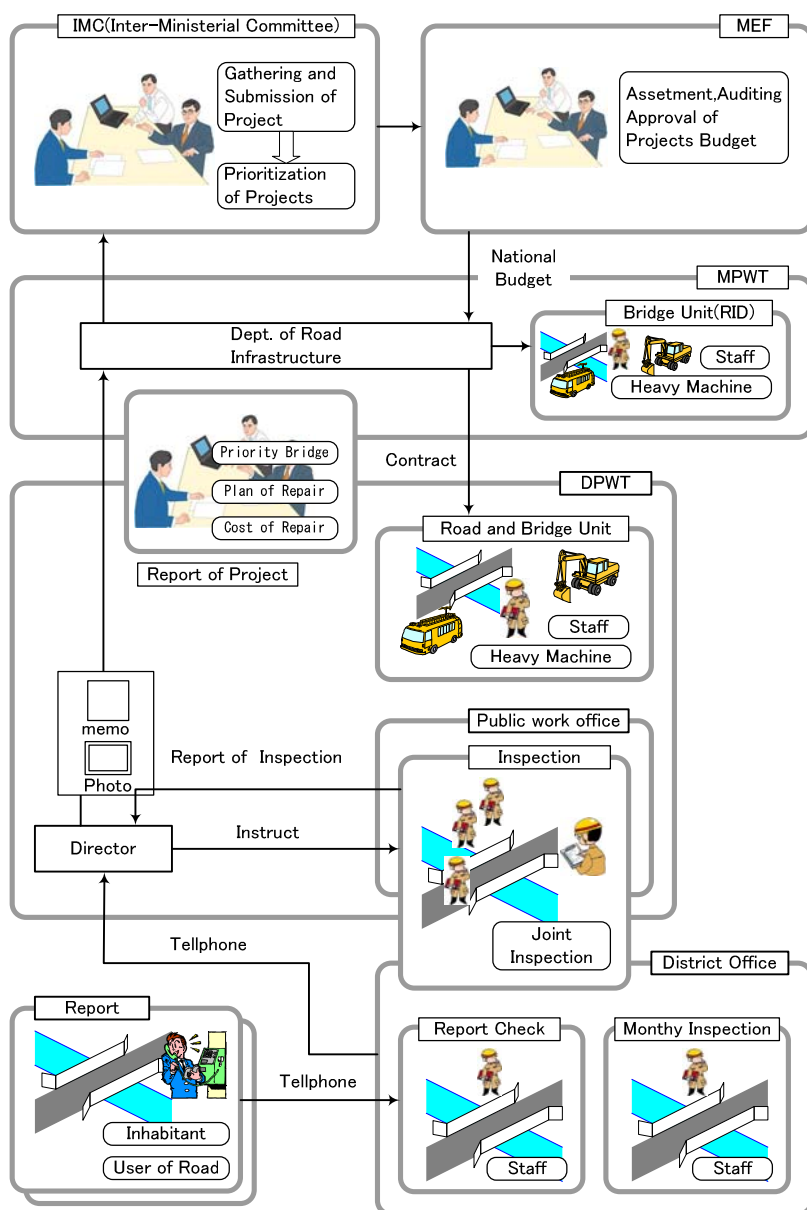


Figure 8-1 Organization relevant to Bridge Maintenance in Cambodia

## 8.2 Road Information in the Cambodia

### (1) Road information managed by the relevant organization

#### 1) Information managed by the RID

The RID collects and readjusts bridge information obtained through the survey by the local offices. However, the bridge data prepared by a local office is not identical with data from other offices because items of the data for bridge management are not yet standardized. Bridge inventory data managed by the Kandal District are shown in Table 8-1. The items in the data are limited to basic information and are insufficient to use for bridge maintenance.

**Table 8-1 Bridge Inventory data of Kandal District**

Item	Description
Road ID	Identification Number of Road
PK	Kilometer post of on the road
Length	Bridge length
Spans/Cells	Number of Span
Province	Administration Office (DPWT)
Str_Type	Structure Type e.g. bridge or culvert
Width	Bridge width
Str_Material	Material of the Bridge
Year of construction	Year the bridge was constructed

#### 2) Information managed by the HEC

Information managed by the HEC was prepared through the bridge inventory survey in 2006 and the information has not been updated to the present. Large number of bridges including Bailey bridges have been replaced since the year 2006 and the information of the HEC does not correspond with the existing condition of bridges. Items entered in the HEC inventory data are shown in Table 8-2.

**Table 8-2 Bridge Inventory data of the HEC**

Item	Description
Road_ID	Identification Number of Road
Link_ID	Identification Number of Link
Structure_ID	Identification Number of Bridge
Structure_Description	Description of Bridge
Run Chain	Kilometer from origin of the road
Length	Bridge length
Spans/Cell	Number of span
Structure_Condition	Condition of structure
Province	Administration Office (DPWT)
Structure_Type	Structure Type e.g. bridge or culvert
Structure_Width	Bridge width
Structure_Material	Material of the Bridge

**(2) Information system for road management in the Cambodia**

Basic structural information of bridges is handled by several information systems, however there is not detailed information necessary for systematic bridge maintenance. The Road Management Systems in the Cambodia are shown in Table 8-3.

**Table 8-3 Road Management System in the Cambodia**

Department	System	Description
RID	—	There is no Road management system
HEC	RAMP	Development of road asset management system is under study. Management for road surface is the main objective of the system however basic structural information of bridge and culvert and their conditions are also planned to record in the system
PWRC (Infrastructure)	Document Data Base System	Document file including design standard, regulation, design document and as build drawing which accumulated in the MPWT are converted into image data. The data is possible to be searched within the system.
PWRC (Topographic)	GIS System	The system was developed through JICA project in 2003. Basic bridge information including road number, location of bridge and structure type are recorded in the system, however the data is not updated to the present.

**(3) Outline of the Road Management System in the Cambodia**

1) Outline of Road Asset Management Project (RAMP)

The RAMP is planned to be developed by the HEC. The system will consist of road pavement management function (HIMS), road investigation system (ROMDAS), System to measure the pavement deflection (FWD) and Basic Map System (ArcGIS) based on the HDM4 (Pavement management system) offer by the World Bank and ADB.

In addition to the inventory of pavement, the system administrates the other inventory data and rank of deterioration of bridges and culverts. The ranks of deterioration for bridges and culverts are recorded as Good, Fair and Poor. Grade of deterioration and total condition of Slab, handrail, guardrail, abutment, pier, expansion joint, traffic sign and bank protection of bridge will be evaluated. , and wall and drainage condition will be evaluated for culverts. The items of inventory data and condition data for bridge and culvert recorded by the RAMP are shown in Table 8-4 and Table 8-5 respectively.

**Table 8-4 Inventory data and condition data for bridge**

No	Field	Option
1	Bridge ID	
2	Bridge Name	
3	Construction Year	
4	Province	
5	Bridge Type	01:Reinforced Concrete 02:Bailey Bridge 03:Steel Truss 04:Composite, 05:Timber 06:Composite 07:Other
6	Road Number	
7	Link ID	
8	Offset	
9	Station(running change)	
10	Number of Spans	
11	Clear Height	
12	Clear width	
13	Load limit	
14	Services	01:Electric 02:Water 03:Telephone
15	Crossing Type	01:Road 02:Railway 03:River/Stream 04:Seasonal Channel
16	Deck width(m)	
17	Surface material	01:Concrete 02:Bituminous 03:Steel 04:Wood
18	Deck Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
19	Guardrail Type	01:Concrete 02:Steel 03:Other
20	Guardrail Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
21	Abutment Type	01:Concrete 02:Other
22	Abutment Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
23	Number of Piers	
24	Pier Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)

No	Field	Option
25	Expansion Joints	01:Good(no action required) 02:Fair(requires cleaning to allow water to escape) 03:Poor( Strong impact or abnormal sound when vehicle pass
26	Road Signs	01:Good(no action required) 02:Fair(requires cleaning or maintenance) 03:Poor(missing or requires replacement)
27	Erosion Protection	01:None 02:Gabion mattress 03:Mortared stone 04:Other
28	Erosion Protection Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
29	Photo along Bridge Deck	
30	Photo from upstream	
31	Photo from downstream	
32	Added by	
33	Added date	
34	Changed by	
35	Changed date	
36	Latest	
37	Committed	
38	Notes	

**Table 8-5 Inventory data and condition data for Culvert**

No	Field	Option
1	Culvert ID	
2	Construction year	
3	Province	
4	Road Number	
5	Link ID	
6	Offset	
7	Station(Running change)	
8	Culvert Type	01:Concrete Pipe 02:Concrete Box 03:Concrete Water Gate 04:Concrete Cause Way 05:RC Slab 06:Other
9	No of Barrels/cells	
10	Pipe Diameter(m)	
11	Cell size (m.x m.)	
12	Road width (meters between headwalls)	
13	Condition	01:Good(no action required) 02:Blocked(requires maintenance) 03:Damaged(requires engineer's assessment)
14	Headwall Type	01:Concrete

No	Field	Option
	(for pipe culverts)	02:Mortared stone 03:Gabion
15	Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
16	Up and Downstream of channel	01:Good(free flow of water) 02:Poor(Channel blocked – requires maintenance)
17	Erosion Protection	01:None 02:Gabion mattress 03:Mortared stone 04:Other
18	Erosion Protection Condition	01:Good(no action required) 02:Fair(requires maintenance) 03:Poor(requires engineer's assessment)
19	Photo along the Deck	
20	Photo from upstream	
21	Photo from downstream	
22	Added by	
23	Added date	
24	Changed by	
25	Changed date	
26	Latest	
27	Committed	
28	Notes	

2) Procurement of software and hardware in the RAMP

Software and hardware are planned to be procured by the RAMP and they are shown in Table 8-6. Some of equipment are useful for establishment of Bridge Management System (BMS) and they shall take into account when a component of hardware and software for the BMS will be examined.

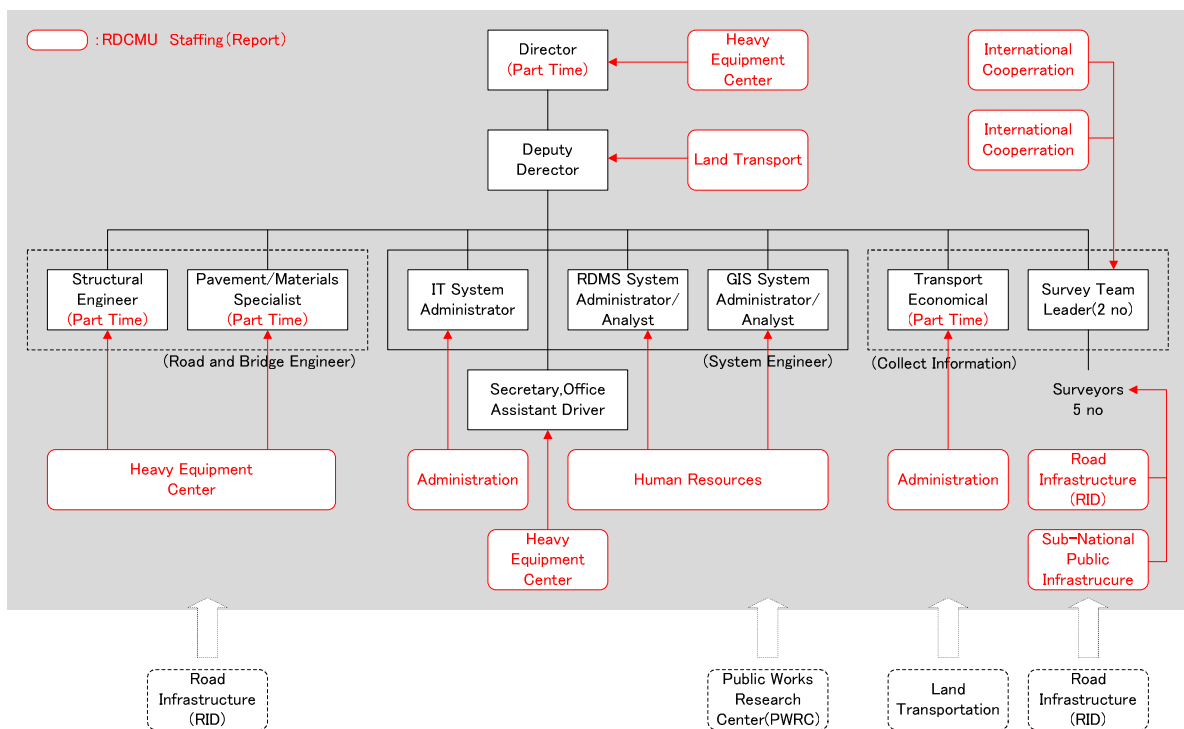
**Table 8-6 Software and Hard ware procured through the RAMP**

Item	Soft or Hard Ware	Contents
ROMDAS	Hard Ware	Two solid laptop personal computer Vehicle for ROMDAS Laser Profilometer Falling Weight Deflectometer (FWD)
	Soft Ware	Maintenance and Upgrade of software for ROMDAS Maintenance of Data
HIMS	Hard ware	One HIMS server Client Personal Computer
	Soft Ware	HDM4 interface with three years maintenance
Arc GIS	Hard Ware	Arc Pad for site survey of bridges and culverts
	Soft Ware	Arc Editor Ver10 Arc View Ver10 with two years maintenance
Others	Hard ware	Two motor cycle for site survey Two PDA for site survey Two Camera for site survey Two hard disk with one tera bite for buck up One Server and three client computer



3) Circumstances of the RAMP

The RAMP is managed by the Road Data Collection Management Unit (RDCMU) established in the MPWT. According to the report issued on March 2012 by the RAMP, members of the relevant divisions of the MPWT were transferred to the RDCMU. However the relationship and responsibilities between the divisions are not clear taken into consider the flow of road maintenance activities. The RDCMU is a special division for collection and management of information and has two major objectives, one is information management and other is site survey to collect inventory of road facilities. Road and bridge engineers work part time and they collect, administer and manage information for road management. Therefore the engineers from the RID and the DPWT will take charge for the new division which has responsibility for the maintenance of roads and bridges. There is a group in the PWRC which handles topographic data and updated road information on the GIS and integration of the group with the new division shall be studied.



**Figure 8-2 Organization of the RDCMU for the RAMP**

4) Document Data Base System

1. Outline of the System

The document Data Base System is developed through the quality control project, and the PWRC, the RID, the HEC, the DPWT are cooperating for the development of the system. The documents including design standards, specifications, reports of project by donor countries and as-built drawings are managed by the system.

2. Items managed by the system

Image file, word file, excel file and compressed file are managed by the system. The system is already operated sufficiently and is now collecting data from the divisions concerning the bridge construction. Items of the data are shown in Table 8-7.

3. System composition

Utilization of the system is limited to registration and access to the document data. Data registration and access to the data shall be operated directly on the web server because the Local Area Network (LAN) system is not yet provided in the MPWT. However, a system is developed to make the staff in the MPWT utilize the system through network. It is possible to restrict the system users by user authentication system on a display when the system starts.

**Table 8-7 Inventory of the Document Data Base**

Title	Detail
Subject	No of Item
Subject ID	OFD/RDB/MT
Type of Document	01: Laws and Regulations 02: Prakas 03: Policy Papers 04: Project 05: Specifications Standards 06: Guidelines 07: Technical Documents 08: Others
Document Detail	01: Study Reports 02: Detail Design 03: Tender/Bidding of Contract documents 04: Completion Report 05: Drawing(Tendering) 06: Drawing(As Built) 07:Others
Fund Source	ADB: Asian Development Bank CHA: CHINA GVT: Government and Year of Approval JPN: JAPAN KRA: KOREA
Project Number	
Project Title	
Document Number	
Document Title	
Completion Year	
Completion Month	
Road Number	
Bridge Number	
Hard Copy	Yes/No
Soft Copy	Yes/No
Reference Code	
Document Code	
Shelf Code	
Abstract	
Province and Capital	01:Banteay Meanchey 02:Battambang 03:Kampong Cham 04:Kampong Chhnang 05:Kampong Speu 06:Kampong Thom 07:Kampot 08:Kandal 09:Koh Kong 10:Kratie(KRATTE)

5) GIS System

The GIS system is developed by the topographic section in the PWRC. Road information and bridge information are included in the system however the bridge information has not been updated since the information of bridges entry through JICA project in 2003. ArcViewGIS3.3 introduced through JICA project is utilized for the GIS system. The information of the GIS cannot be contacted through network therefore limited staff are able to utilize by the copy of the data. Structural information of bridges stored in the GIS system is listed in Table 8-8.

**Table 8-8 Structural data stored in the GIS**

Name	Data Format	Indication	Description	Remark	
Location	Route	Character	RN####	Route Name	Municipal Roads
	Number	Binary	###	Continuous Structure Number of Each Road Route, Additional Comments of Data as Remarks	
	Rem	Character			
	GPS Position	Character	48 P XXXXXX YYYYYY	GIS base Locations, using India-Thai Datum	JICA GIS BASE MAP
	X	Binary	XXXXXX	6-digits for X coordinates on India-Thai Datum	
	Y	Binary	YYYYYYY	7-digits for Y coordinates on India-Thai Datum	
Structure	Type	Character	TTTTTT	Bridge/Culvert/Ferry/Toll Gate	
	Type2	Character	See Table A	Detail Structure Type	
	Type3	Character	See Table B	Bridge Girder Type or Culvert Cell Numbers	
	Deck Type	Character	See Table C	Bridge Deck Type	
Dimensions	Length m	Binary	####.#	Overall Bridge Length m	
	a<L<b	Binary	#	For Span Length Classification	
	L=<20m	Binary	1	less 20 m	
	20<L=<50m	Binary	2	over 20 m, up to 50 m	
	50<L	Binary	3	over 50 m	
	Width m	Binary	##.#	Lane and Sidewalk Width m	
	a<W<b	Binary	#	For Width Classification	
	W=<4	Binary	1	less 4m	
	4<W=<6m	Binary	2	over 4m, up to 6m	
	6<W=<10	Binary	3	over 6m, up to 10m	
10<W	Binary	4	over 10m		
Projects	Funds	Character	FFFFFFF	Funding Sources, ADB, WB, Japan and so on	
	Project	Character	PPPPPPP	Abbreviations of Project Name	
	Activities	Character	AAAAAAA	NEW, RETAIN, REPAIR, SEEKING	
	Progress	Character	PPPPPPP	Completed, Ongoing, Seeking	
	Completion Year	Character	M-YYYY	Referred to Project Contract Documents	

### **8.3 Information Management for Bridge Maintenance**

#### **(1) Existing bridge maintenance activity and flow of information**

Bridge information shall be collected and accumulated in the database for repair or replacement of bridges in near future since structural data and inspection data necessary for the bridge maintenance are not sufficient in the Cambodia. It is important that the structural data and inspection data shall be accumulated efficiently taking into consider the flow of the bridge maintenance activities. Entry and update of the bridge data will be carried out on three occasions, 1. Just after the bridge is constructed, 2. When bridge is inspected, and 3. Just after the bridge is repaired. Entry and update of the bridge information shall be unified into a division in charge because bridge information in different status is managed by several divisions in the Cambodia. The occasions for updating the bridge information and division in charge are shown in Table 8-9. The bridge information and divisions in charge are shown in Figure 8-3.

**Table 8-9 Existing flow of data update in the Cambodia**

<b>Action Phase</b>	<b>Department</b>	<b>Make/Change Information</b>
Construction of Bridge	MPWT(HEC) MPWT(RID,Bridge Unit) DPWT (Road and Bridge UNIT)	Inventory Data of Bridge →Make New Data
Inspection of Bridge	DPWT Public Work Office	Inspection Data of Bridge →Rating Data
Repair of Bridge	MPWT(RID,Bridge Unit) DPWT (Road and Bridge UNIT)	Repair Data of Bridge →Make Repair Method Data →Make Cost of Repair Data Inventory Data of Bridge →Change Inventory Data Inspection Data of Bridge →Clear Rating Data

	Execute	Information	Make System
	Maintenance	List of EXCEL (2,000Bridge)	
	Repair Construction	Planing of Repair Cost of Repair	
MPWT	Construction	List of EXCEL (2,300Bridge) JICA 2006 Years	RAMP HDM4/HIMS ROMDAS ArcGIS(Ver10)
	Collect Document	Report of Design Drawing of Bridge	Database of Document
		List of EXCEL (1,772Bridge) JICA 2003 Years	Arc View3.3 (Position)
DPWT	Inspection Report of Inhabitant Monthly Inspection Repair	List of EXCEL	

**Figure 8-3 Bridge Information and division in charge**

**(2) Management of information from bridge inspection**

Bridge information is collected based on the inspection sheet by the site survey in this project. The bridge information collected and stored in the database is converted into a list to make the reference of the information simple. The method where bridge information in the database is converted into the bridge list is useful to manage the bridge database system in the future. Inspection sheets used in this project are shown in Table 8-10 and Table 8-11. The process by which bridge information in the database is converted in to bridge list is shown in Figure 8-4. The bridge information shall be identified by its coordinates and the coordinates are converted into Google earth map and it is shown in Figure 8-5.

**Table 8-10 Bridge Inspection Sheet (1)**

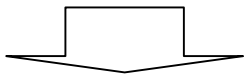
	A	B	C	D	E	F	G	H	I	J
1										
2		<b>1. General Information of the Bridge Inventory</b>							Note: Under Construction	
3		Inspector :	Date	Month	Year	1.2 Coordinate		*	*	**
4		1.1 Inspection date			2012	North latitude				
5		1.1 Bridge Name				East longitude				
6		1.1 Province				1.1 Road Number				
7		1.1 River Name				1.4 Width of River (m)				
8			Date	Month	Year	1.6 Geographical features				
9		1.3 Construction Year				1.7 Clearance (m)			1. Flat plane 2. Gentle hill 3. Steep mountain	
10		1.9 Loading capacity (t)				1.8 Maximum high water level (m)				
11		1.9 Width limit (m)				1.9 Vertical clearance(m)				
12		1.5 Particle size								
13		1.10 Type of the life line								
14		1.11 Material of surface layer								
15		1.12 Material of Deck								
16		1.13 Material of Guardrail								
17		1.14 Embankment protection								
18		2.3 Cross sections	1	2	3	4	5	6	7	Total width
19		W (cm)								

**Table 8-11 Bridge Inspection Sheet (2)**

	A	B	C	D	E	F	G	H	I	J
1										
2		<b>2. Dimensions of Super Structure</b>								
3		Bridge Length (m)								
4		2.1 Span No.		2.4 Type of bridge		2.4 Type of girder		2.1 Hight of girder (cm)	2.2 Length of span (m)	
5		1								
6		2		1. Bailey 2. Wood 3. Steel						
7		3		4. Concrete						
8		4		5. Stone 9. Others						
9		5								
10		6								
11		7								
12		8								
13		9								
14		10								
15		<b>3. Dimensions of Sub Structure</b>								
16		2.1 Item		3.2 Type of abutment and pier		3.1 Height (m)		Material of Pile		
17		A1								
18		A2								
19		P1								
20		P2								

Inspection Sheet

1	1. General Information of the Bridge Inventory										
2	Inspector	Date	Month	Year	1.2 Coordinate						
3	Inspection date	28	4	2012	North latitude						
4	Bridge Name	Kouk Kdouch			East longitude						
5	Province	Banteay Meanchey			Road Number						
6	River Name	Unknown			Width of River (m)						
7	Construction Year	Date	Month	Year	Geographical features						
8	Construction Year			Unknown	Clearance (m)						
9	Loading capacity (t)	None			Maximum high water level (m)						
10	Loading capacity (t)	None			Vertical clearance(m)						
11	Width limit (m)	None			Particle size						
12	Width limit (m)	1	Fine			Type of the life line					
13	Particle size	1	Fine			Material of surface layer					
14	Type of the life line	2	Concrete			Material of Deck					
15	Material of surface layer	1	Concrete			Material of Guardrail					
16	Material of Deck	1	Concrete			Embankment protection					
17	Material of Guardrail	1				Cross sections					
18	Embankment protection	1				W (cm)					
19	Cross sections	1	2	3	4	5	6	7	Total width		
20	W (cm)	21	-	407	-	-	-	22	450		
21											
22											
23											



Information of Inspection Sheet is convert into Bridge

1	インポート	Kmファイル作成	諸元設定										
2	列数	14											
3	Sheet Name				Information	Information	Information	Information	Information	Information	Information	Information	Dim
4	抽出セル(行)				4	4	4	5	5	5	5	6	
5	抽出セル(列)				8	9	10	8	9	10	8		
6	No.	Filename	Route Number	sig	No.	North latitude				East longitude		Road number	Br
7	1	SJEB-R154-0001.xlsx	154		1	12	32	51.4	103	55	16.5	154	
8	2	SJEB-R154-0002.xlsx	154		2	12	35	4.5	103	57	22.2	154	
9	3	SJEB-R154-0003.xlsx	154		3	12	35	4.7	103	57	41.7	154	
10	4	SJEB-R154-0005.xlsx	154		4	12	36	48.0	103	59	29.0	154	
11	5	SJEB-R154-0006.xlsx	154		5	12	37	26.4	104	0	26.2	154	
12	6	SJEB-R154-0007.xlsx	154		6	12	37	6.8	104	0	59.1	154	
13	7	SJEB-R154B-0001.xlsx	154	B	1	12	39	59.7	103	52	17.5	154B	
14	8	SJEB-R154F-0001.xlsx	154	F	1	12	40	41.1	103	38	34.0	154F	
15	9	SJEB-R154F-0003.xlsx	154	F	2	12	42	30.4	103	38	9.1	154F	
16	10	SJEB-R154F-0004.xlsx	154	F	3	12	42	44.6	103	38	4.7	154F	
17	11	SJEB-R154F-0005.xlsx	154	F	4	12	44	15.3	103	37	32.6	154F	
18	12	SJEB-R155-0001.xlsx	155		1	12	30	54.6	103	55	16.8	155	
19	13	SJEB-R155-0002.xlsx	155		2	12	30	43.3	103	55	15.3	155	
20	14	SJEB-R155-0003.xlsx	155		3	12	30	21.4	103	55	12.4	155	
21	15	SJEB-R155-0004.xlsx	155		4	12	29	58.1	103	55	9.2	155	
22	16	SJEB-R155-0005.xlsx	155		5	12	29	34.5	103	55	6.1	155	
23	17	SJEB-R155-0006.xlsx	155		6	12	28	0.1	103	54	3.8	155	
24	18	SJEB-R155-0007.xlsx	155		7	12	27	49.5	103	53	47.2	155	
25	19	SJEB-R155-0008.xlsx	155		8	12	22	17.7	103	47	27.0	155	
26	20	SJEB-R155-0009.xlsx	155		9	12	20	56.3	103	46	24.2	155	
27	21	SJEB-R155-0010.xlsx	155		10	12	17	16.1	103	48	23.0	155	

Click

Multiple information are possible to confirm and referred on the bridge list

1	1. General Information of the Bridge Inventory										
2	Inspector	Date	Month	Year	1.2 Coordinate						
3	Inspection date	28	4	2012	North latitude						
4	Bridge Name	Kouk Kdouch			East longitude						
5	Province	Banteay Meanchey			Road Number						
6	River Name	Unknown			Width of River (m)						
7	Construction Year	Date	Month	Year	Geographical features						
8	Construction Year			Unknown	Clearance (m)						
9	Loading capacity (t)	None			Maximum high water level (m)						
10	Loading capacity (t)	None			Vertical clearance(m)						
11	Width limit (m)	None			Particle size						
12	Width limit (m)	1	Fine			Type of the life line					
13	Particle size	1	Fine			Material of surface layer					
14	Type of the life line	2	Concrete			Material of Deck					
15	Material of surface layer	1	Concrete			Material of Guardrail					
16	Material of Deck	1				Embankment protection					
17	Material of Guardrail	1				Cross sections					
18	Embankment protection	1				W (cm)					
19	Cross sections	1	2	3	4	5	6	7	Total width		
20	W (cm)	21	-	407	-	-	-	22	450		
21											
22											
23											

Figure 8-4 Process of bridge information in the database convert in to bridge list

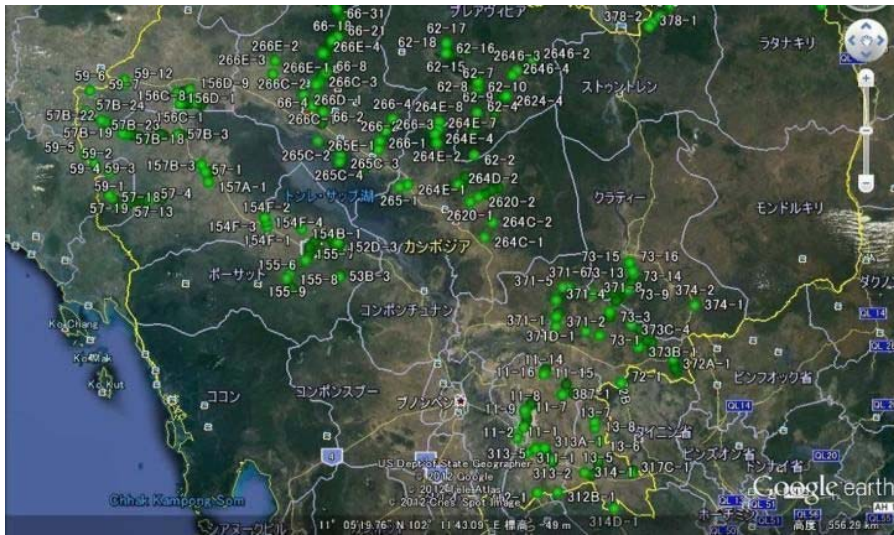


Bridge locations on the list

A			B			C			D			E			F			G			H			I			J			K			L		
1	インポート		Kmファイル作成			設定																													
2	列数		14																																
3	Sheet Name																																		
4	抽出セル(行)																																		
5	抽出セル(列)																																		
6	No.	Filename	Route	Number	elig	No.	North latitude	East longitude	Road number	Bri																									
8	1	SIEB-R154-0001.xlsx	154			1	12	32	51.4	103	55	165	154																						
9	2	SIEB-R154-0002.xlsx	154			2	12	35	4.5	103	57	222	154																						
10	3	SIEB-R154-0003.xlsx	154			3	12	35	4.7	103	57	41.7	154																						
11	4	SIEB-R154-0005.xlsx	154			4	12	36	48.0	103	59	29.0	154																						
12	5	SIEB-R154-0006.xlsx	154			5	12	37	28.4	104	0	28.2	154																						
13	6	SIEB-R154-0007.xlsx	154			6	12	37	6.8	104	0	59.1	154																						
14	7	SIEB-R154B-0001.xlsx	154	B		1	12	39	59.7	103	52	17.5	154B																						
15	8	SIEB-R154F-0001.xlsx	154	F		1	12	40	41.1	103	38	34.0	154F																						
16	9	SIEB-R154F-0003.xlsx	154	F		2	12	42	30.4	103	38	9.1	154F																						
17	10	SIEB-R154F-0004.xlsx	154	F		3	12	42	44.6	103	38	4.7	154F																						
18	11	SIEB-R154F-0005.xlsx	154	F		4	12	44	15.3	103	37	32.6	154F																						
19	12	SIEB-R155-0001.xlsx	155			1	12	30	54.6	103	55	16.8	155																						
20	13	SIEB-R155-0002.xlsx	155			2	12	30	43.3	103	55	15.3	155																						
21	14	SIEB-R155-0003.xlsx	155			3	12	30	21.4	103	55	12.4	155																						
22	15	SIEB-R155-0004.xlsx	155			4	12	29	58.1	103	55	9.2	155																						
23	16	SIEB-R155-0005.xlsx	155			5	12	29	34.5	103	55	6.1	155																						
24	17	SIEB-R155-0006.xlsx	155			6	12	28	0.1	103	54	3.8	155																						
25	18	SIEB-R155-0007.xlsx	155			7	12	27	49.5	103	53	47.2	155																						
26	19	SIEB-R155-0008.xlsx	155			8	12	22	17.7	103	47	27.0	155																						
27	20	SIEB-R155-0009.xlsx	155			9	12	20	56.3	103	46	24.2	155																						
28	21	SIEB-R155-0010.xlsx	155			10	12	17	16.1	103	48	23.0	155																						



Bridge location indicated on the Google Earth Map



Bridge location confirmed on the Map

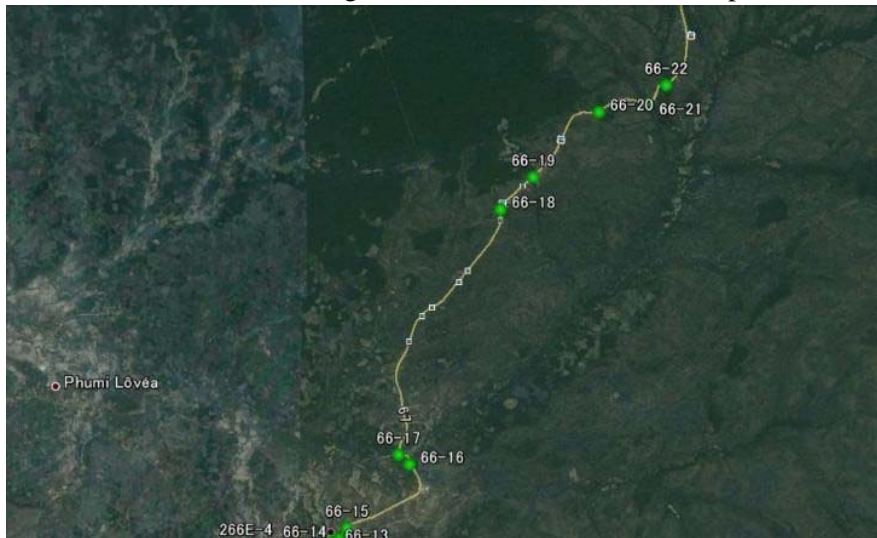


Figure 8-5 Coordinate of bridges converted into Google Earth Map

## **8.4 Development of the Bridge Management System**

### **(1) Basic Policy of the System Development**

Basic policy for development of bridge management system is shown as follows. Practical contents for the system shall be discussed through a future project.

#### **1) Role of the Bridge Management System**

BMS is not mere software but a total system which combines engineers, organizations, tools and manuals into management and implements the bridge maintenance continuously.

#### **2) Unification of the data**

Data relevant to bridge management including structural data, inspection data design drawings and as built drawings maintained by several division of the MPWT shall be unified into one system in principle. The unification of data management through network is not applicable in the existing circumstances in the MPWT. Therefore, design documents and drawings shall be managed by document data base and bridge structural data, inspection data and repair record shall be managed by the data base for the bridge maintenance.

#### **3) Clarification of the flow of data management**

Data for bridge maintenance including structural data, inspection data and repair record shall be maintained continuously. Responsibility of each division concerning the bridge maintenance and flow of the data shall be clarified.

#### **4) Preparation of manuals relevant to bridge maintenance**

Bridge inspection manual for proper evaluation of bridge conditions and bridge maintenance manual shall be prepared. Seminars for the manuals have to be held for exact understanding of bridge maintenance by inspectors.

#### **5) Study the system component considering the environment in the MPWT**

System component including stand-alone system, central and server system and web system shall be studied taking into consider the progress of the network environment, saturation level of the personal computer, schedule of the procurement of other systems and system users. Hardware and software necessary for the system operation shall be clear.

#### **6) Method for identifying bridges**

There are lot of bridges without their own names so they shall be distinguished and administered by the road number, coordination, and sequential no on the road. The system need to have a function to mark the location of the bridge on the map.

#### **7) Function of the system**

Basic functions necessary for the Bridge Management System are as follows

- a) Support the input of bridge inspection information
- b) Evaluation of the bridge deterioration and prioritization for repair based on the inspection report
- c) Planning for bridge repair and estimate the repair cost
- d) Output of bridge information

Various departments in the government and business world are involved in the operation of BMS because the bridges are important social infrastructure and their maintenance needs support from various areas. Organization and responsibility for the bridge maintenance for each division within the MPWT and the DPWT need to be discussed for proper operation of BMS. Image and functions of the BMS are shown in Figure 8-6.

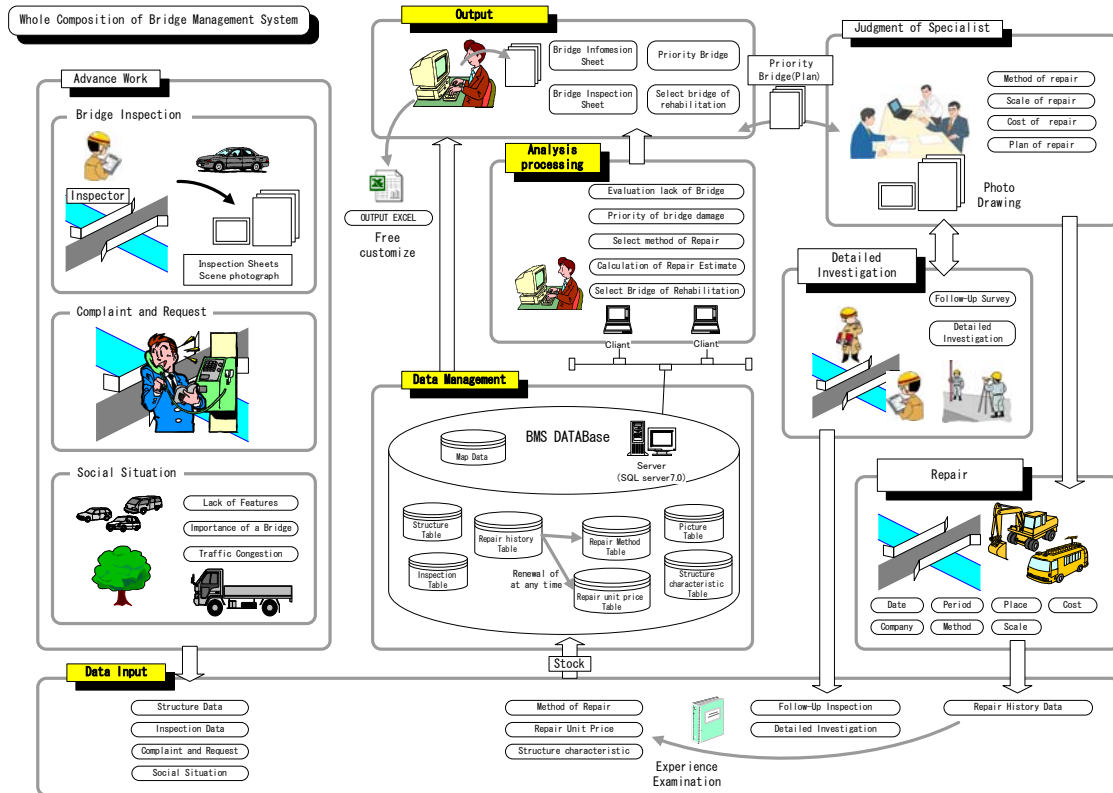


Figure 8-6 Image of the Bridge Management System

(2) Items and data composition in the Bridge Data Base

Items and data composition in the Bridge Data Base are shown in Figure 8-7.

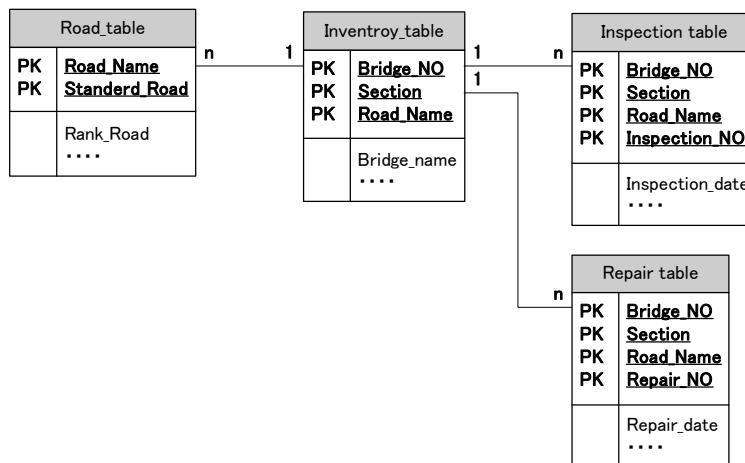


Figure 8-7 Component of the bridge database



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**CHAPTER 9**  
***ENVIRONMENTAL AND***  
***SOCIAL CONSIDERATIONS***

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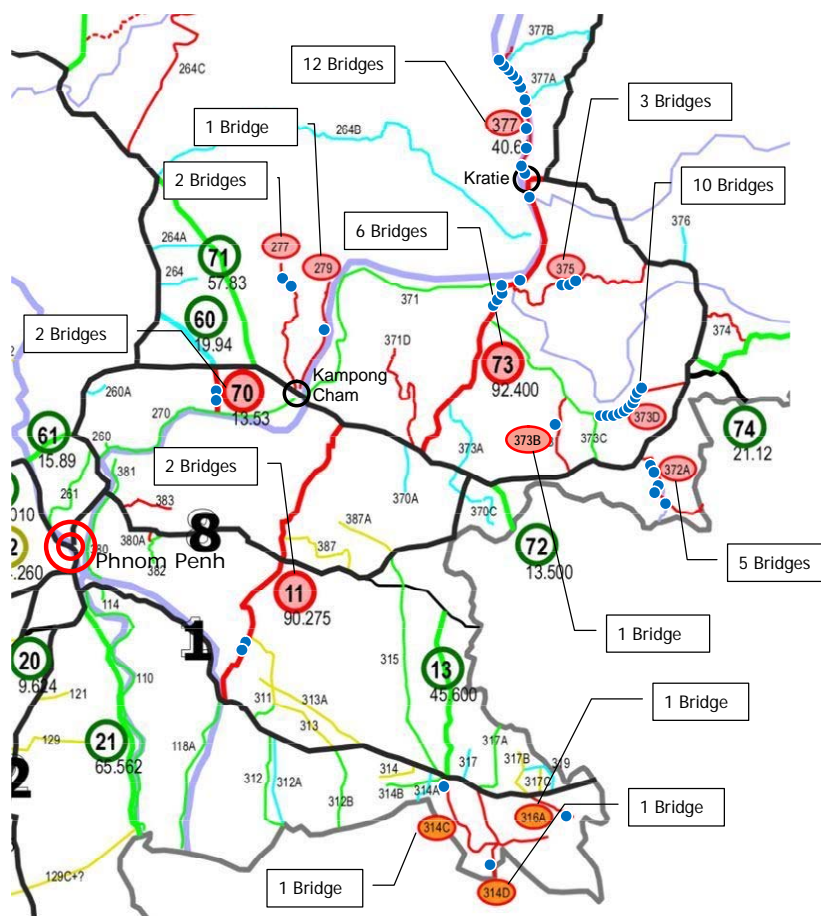


## 9. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

### 9.1 Project Components

The Study Team prioritized 47 bridges on 13 roads in the Section 2.3. Lengths of the bridges are from minimum 10 metres up to maximum 150 metres. Only four bridges have over 100 metres in length. For these bridges, they have no large-scale, and the expected project activity is replacement of the existing bridges, therefore, basically it does not significantly change the existing environmental and social conditions. As the process of replacement consists of construction of diversion including temporary bridge, building of construction road, demolition and clearance of the existing bridge, and construction of new bridge, most likely slight impacts to the environment are expected in the construction period.

13 roads and 47 bridge sites are located in four provinces, i.e. Kampong Cham, Kratie, Prey Veng, and Svay Rieng in the east of the country as shown in Figure 9-1. Physical features around them are not mountainous but comprise flat plains or gentle hills.



Source: Study Team

Figure 9-1 Locations of the Prioritized Roads and Bridges

## **9.2 Outlines of the Project Sites**

### **9.2.1 General Natural Conditions**

#### **(1) Topography**

Topographical condition is generally flat with maximum elevation up to 7 metres for the bridge number 2 and on NR11 in Prey Veng province. In Kampong Cham province, the topographical conditions around the bridges are generally flat with maximum elevation up to 25 m, except for the bridges numbers 1,2,3,4 and 5 on PR372A and bridge numbers on PR373B which is gentle hill with maximum elevation up to 95 metres. In Kratie province, the topographical conditions are also generally flat with maximum elevation from 10 to 25 metres. In Svay Rieng, the topographical conditions are generally flat with maximum elevation from 3 to 5 m.

Soil type in the Prey Veng is alluvium tending to retain water more than rocky or sandy soils. Generally, the province is well known as one of the largest rice producing provinces since it is located in a medium productivity soil. In the Kampong Cham, the soils consist of basalt of the hilly lands surrounded by soils formed from deposition. The basalt soils have highly fertility for a range of cropping and have high water holding capacity, while the alluvial soils have medium fertility. Generally, the province is well known as the agricultural centre of Cambodia. In Kratie, soil types are alluvium and siltstone-sandstone, which are medium productivity soils. Therefore, the Study area has a growing agricultural sector, producing maize, cassava, sesame, sweet potato, sugarcane, soya beans, mung beans, black pepper, sugar cane and cashew nuts. Besides, the province is well known as a major rubber producer of the country. The Svay Rieng province is well known as a major rice producer of the country.

#### **(2) Climate**

The Study area has a predominantly monsoon climate and has been described as tropical wet and dry due to the distinct seasonal variation. Approximately 70-80% of annual rainfall occurs from mid-May to late September or early October. The northeast monsoon brings drier and cooler air from early November to March. The hotter conditions prevail in April and early May as dry season.

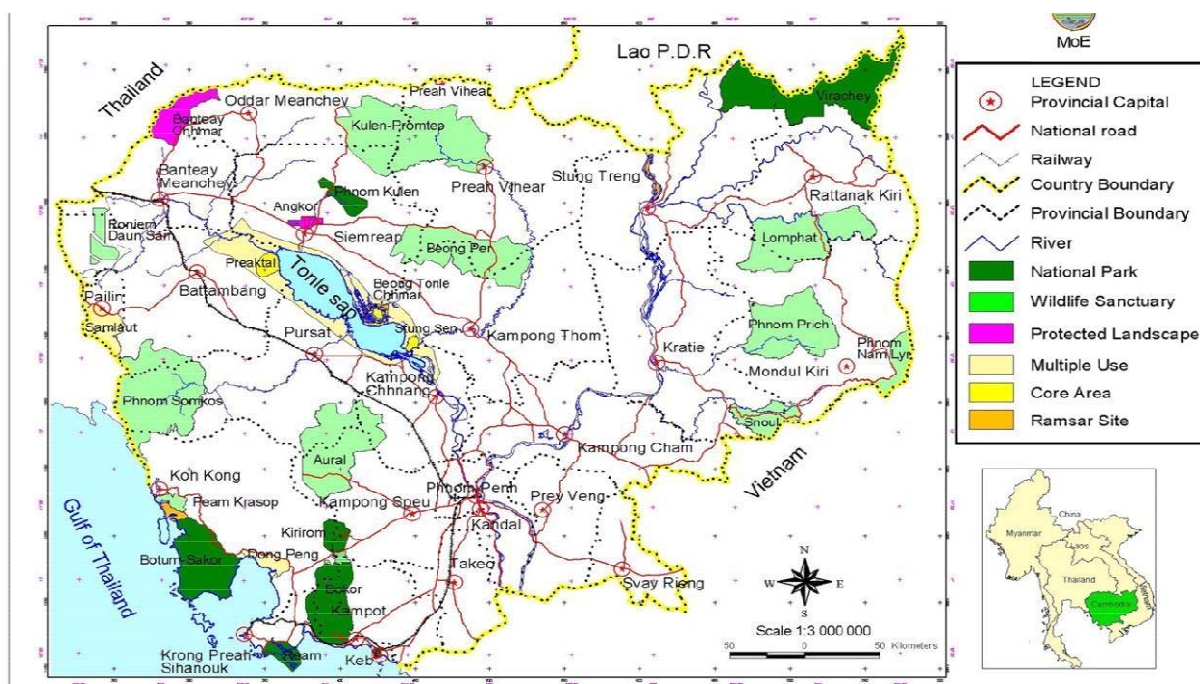
In Prey Veng, daily temperature varies between maximum of 37°C, during the hottest months of April and May, to 17°C in December and January, the coldest months. Daily minimum temperature varies from 8 to 11°C. The average annual rainfall from 1984 – 2010 was 1,379 mm. In Kampong Cham, the hot season lasts from March to June, with the peak



temperature in April at an average daily maximum of 36°C. The coolest month is January with an average daily maximum of 21°C. The annual rainfall is 1,381.5 mm. In Kratie, the an average daily maximum is 36°C. The coolest month is January with an average daily maximum of 20.5°C. The annual rainfall is 1,986.3 mm. In the Svay Rieng, daily temperature varies between maximum of 37°C during the hottest months of April to May and 17°C in December and January, the coldest months. Daily minimum temperature varies from 8 to 11°C. The annual rainfall between 1983 and 2010 varies from 1,300 to 2,200 mm. The average annual rainfall is 1,709 mm.

### (3) Protected Areas

Protected conservation areas cover approximately 5.4 million hectares in the national territory. They consist of seven national parks, nine wildlife sanctuaries, three protected landscape areas, and three protected areas. The national parks are located in the coastal, mountain, plateau and lake regions covering 742,300 hectares and 4,138,000 hectares for wildlife sanctuaries. The protected landscape areas cover 97,000 hectares including archaeological and cultural sites, and protected areas cover 403,900 hectares. However, there are no protected areas around the locations of the bridges.



Source: MOE

**Figure 9-2 Locations of Protected Areas**

## **9.2.2 Route-side Socio-economic Conditions**

### **(1) NR11 (Bridge No. 11-2/3)**

#### 1) Local Administration

The bridge numbers 2 and 3 on NR11 are located passing Ba Boang village in Ba Boang commune of Peam Ro district, Prey Veng province.

#### 2) Population

In the village, total families are 579 with total population of 2,656 people, all of whom 1,361 (51.2%) are women. Average family size is 4.6 persons per family.

#### 3) Living Conditions and Social Services

Major indicators of living conditions and industrial aspects described in the table below show that the area is typical rural area in Cambodia. The families have no electricity, a little access to latrines, no pipe water supply and mainly make a living from agriculture.

#### 4) Transportation

The bridges are located on the NR11, which is one of the main roads in the country and links Kampong Cham and Neak Loeung. People in the province mostly use the road for travelling to Phnom Penh city (approximately 2.5 hours by car) and also transport their agricultural products (mainly rice) to Vietnam's border (about 2 hours by car). Mini-buses and cars are widely used, while motorbike and bicycle are the common transportation means for the local people.

### **(2) NR70 (Bridge No. 70-1/2)**

#### 1) Local Administration

The bridge numbers 1 and 2 on NR70 are located in Peam Khnong and Por Sala II villages, Prek Krabao commune of Kang Meas district, Kampong Cham province.

#### 2) Population

In the villages, total families are 456 with total population of 1,928 people, all of whom 972 (50.4%) are women. Average family size is 4.2 persons per family.

#### 3) Living Conditions and Social Services

Major indicators of living conditions and industrial aspects described in the table below show that the area is comparatively urbanized in Cambodia. 30% families have electricity, fair access to latrines, high use of pipe water and mainly make a living from agriculture.

4) Transportation

The bridges are located on the NR 70 which is one of the main roads in the province and links Kang Meas and National Road 7. Local people in the district mainly use the road for travelling to Kampong Cham town and also to Phnom Penh city. Transporting of agricultural products within the district to Prey Toteung (Along the NR 7) is common. Mini-buses are widely used, while motorbike and bicycle are the common transportation means for local people.

**(3) NR73 (Bridge No. 73-4/5/6/7/8/16)**

1) Local Administration

The bridge numbers are 4, 5, 6, 7, 8 and 16 on NR73 located in Dam Bae district of Kampong Cham province and Chhlong and Kratie districts of Kratie province. Based on the observation, three bridges, specifically bridge numbers 4, 8 and 16 have residents living nearby.

2) Population

In the villages, total families living in the villages around the bridges are 2,377 with total population of 12,143 people, of whom 6,283 (51.7%) are women. Average family size for these villages consists of 5.1 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is comparatively urbanized in Cambodia except the village of Kampong Raing which is located at the middle of NR73. Most families have electricity and toilet facilities, and mainly make a living from agriculture. Pipe water use is limited especially in Rokar Kandal II village which is located close to Kratie town.

4) Transportation

The bridges are located on the NR 73, which is one of the main roads in the province and about 3 hours driving from Phnom Penh. The road is used for going to Stung Treng and also Mondulokiri provinces. The road is used as a route for large buses. Mini-bus is a common transportation means for either passengers or agricultural products. Motorbike and bicycle are the common transportation means for local people. Also, local people mostly use the road for transporting their agricultural products to the Vietnam border.

**(4) PR277 (Bridge No. 277-3/4)**

1) Local Administration

The bridge numbers 3 and 4 on PR277 are located in Peam Khnong and Por Sala II villages, Prek Krabao commune of Kang Meas district, Kampong Cham province.

2) Population

In the villages, total families in the villages around the bridges are 593 with total population of 2,522 people of whom 1,316 (52.2%) are women. Average family size of these villages is 4.3 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is typical rural area in Cambodia. The people have no electricity, a little access to latrines and no pipe water supply and mainly make a living from agriculture.

4) Transportation

The bridges are located in the rural area in Stung Trang district of Kampong Cham province. Motorbike and bicycle were found as the common transportation means for local people. Mini-bus and other cars were seldom found on this road. Traffic was not so active on the road.

**(5) PR279 (Bridge No. 279-7)**

1) Local Administration

The bridge number 7 on PR279 is located past Hann Chey village in Hann Chey commune of Kampong Siem district, Kampong Cham province.

2) Population

In the village, total families in the village around the bridge number 7 are 325 with total population of 1,616 people, of whom 830 (51.4%) are women. Average family size consists of 4.9 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is rather urbanized area in Cambodia. Hann Chey village is located close to Campong Cham town. The people have no electricity and mainly make a living from agriculture.

4) Transportation

The bridge is located at the rural area of Kampong Siem district (about 20 kilometres from Kampong Cham town) and connects to Stung Trang and Chamkar Leu districts. Mini-bus and other cars were found along this road. Motorbike and bicycle were found as the common transportation means for local people.

**(6) PR372A (Bridge No. 372A-1/2/3/4/5)**

1) Local Administration

The bridge numbers 1 to 5 on PR372A are located in Chrey Leung, Mkhos, Kravien Cheung, Choam Kravien villages of DaungChoam Kravien commune of Memot district, Kampong Cham province.

2) Population

In the villages, total families living in the villages around the bridges are 935 with total population of 4,355 people, all of whom 2,191 (50.3%) are women. Average family size consists of 4.7 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is comparatively urbanized in Cambodia. Most families have electricity and toilet facilities, and mainly make a living from agriculture.

4) Transportation

The bridges are located in the rural area of Memot district (about 20 kilometres from the district center) and the road connects to Vietnam's border (about 15 kilometres). The road is used to transport agricultural products to either the Vietnam border or other places. Motorbike and bicycle were found as the common transportation means for local people.

**(7) PR373B (Bridge No. 373B-1)**

1) Local Administration

The bridge number 1 on PR373B is located past Chamkar Thmey village in Koki commune of Memot district, Kampong Cham province.

2) Population

In the village, total families in the village around the bridge number 1 are 239 with total population of 1,152 people, of whom 593 (51.5%) are women. Average family size consists of 4.8 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is a little urbanized in Cambodia. Some families have electricity and use latrine although most families use borehole and open well and mainly make a living from agriculture.

4) Transportation

The road passes the rural area of Memot district and connects to NR7. It is used to transport agricultural products to either the Vietnam border or other places. Motorbike and bicycle were found as the common transportation means for local people.

**(8) PR373D (Bridge No. 373D-1/2/3/4/5/6/7/9/10/12)**

1) Local Administration

The bridges except bridge number 1 on PR373D are located in Sampov Loun and Kabas villages, Cham Tamao and Memorng communes, in Memot district of Kampong Cham province. The bridge number 1 is located in Sa Art village, Sre Char commune in Snuol district of Kratie province.

2) Population

In the villages, total families living in the villages around the bridges are 1,202 with total population of 5,299 people, all of whom 2,694 (50.8%) are women. Average family size consists of 4.4 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is a typical rural area in Cambodia. The people have no electricity, no access to latrine, no pipe water supply and mainly make a living from agriculture.

4) Transportation

The bridges are located in the rural area of Memot district. The road connects to NR7 and there is little traffic on the road. Motorbike and bicycle were found as the common transportation means for local people.

**(9) PR375 (Bridge No. 375-2/3/4)**

1) Local Administration

The bridge numbers 2 to 4 on PR375 are located in Kroch village, Damrei Phong commune of Chhlong district in Kratie province.

2) Population

In the village, total families living in the village around the bridges are 141 with total population of 625 people, of whom 307 (49.1%) are women. Average family size consists of 4.4 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is a typical rural area in Cambodia. The people have no electricity, very little toilet use, no pipe water supply and mainly make a living from agriculture.

4) Transportation

The bridges are located in the rural area of Chhlong district. The road passes agricultural area, the width is narrow and surface condition is very bad. The traffic was little and farm car, motorbike and bicycle were found as the common transportation means for local people.

**(10) PR377 (Bridge No. 377-1/2/3/4/5/6/7/8/9/10/11/12)**

1) Local Administration

The bridge numbers 1 to 12 on PR377 are located passing 10 villages, five communes in three districts: Kratie, Chet Borey, and Sambo, Kratie province.

2) Population

In the villages, total families living in the villages around the bridges are 4,107 with total population of 19,141 people, of whom 9,579 (50.0%) are women. Average family size for these villages is 4.7 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is comparatively urbanized in Cambodia. Most families have electricity and access to latrines, and mainly make a living from agriculture. However, for water sources, only two villages which are located close to Kratie town use pipe water, while boreholes and open wells are used in the other villages.

4) Transportation

The bridges are located on PR377, which is one of the main roads in the province and connects to Kratie town. Mini-bus, motorbike and bicycle are the common transportation means for local people. Also, people mostly use the road for transporting their agricultural products to provincial towns.

**(11) PR314C (Bridge No. 314C-1)**

1) Local Administration

The bridge number on PR314C is located in Tarang Bal village, Koy Trabaek commune of Svay Rieng town, Svay Rieng province.

2) Population

In the village, total families living in the village around the bridge are 360 with total population of 1,415 people, of whom 745 (52.6%) are women. Average family size is 3.9 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is comparatively urbanized in Cambodia. Most families have electricity and access to latrines. However, for water sources, the families use open well in the village, and mainly make a living from agriculture.

4) Transportation

The bridge is located at Svay Rieng town which has the time distance to Phnom Penh about 2.30 hours, while the Vietnam border is close. Mini-buses, motorbikes, and cars are widely used as the common transportation means for local people.

**(12) PR314D (Bridge No. 314D-1)**

1) Local Administration

The bridge is located in O village, Thmey commune of Kampong Roa district, Svay Rieng province.

2) Population

Total families living in the village around the bridge are 360 with total population of 1,415 people, of whom 745 (52.6%) are women. Average family size consists of 3.9 persons per family.

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is a typical rural area in Cambodia. The route connects to the Vietnam border passing through agricultural area. Some families use toilet facilities, while boreholes are the source of water use and families mainly make a living from agriculture, although the village is electrified.



4) Transportation

The bridge is located in the rural area of Kampong Roa district. It takes about 30 minutes to the Vietnam border and about 50 minutes to the provincial town from the bridge. Mini-buses, motorbikes, and cars are widely used and are the common transportation means for local people. Trucks hauling agricultural products for export and import products pass on the road to/from the Vietnam border.

**(13) PR316A (Bridge No. 316A-1)**

1) Local Administration

The bridge number on PR316A is located in Bos village, Me Sor Thngork commune of Chantrea district, Svay Rieng province.

2) Population

In the village, total families living in the village around the bridge are 252 with total population of 1,003 people, of whom 515 (51.3%) are women. Average family size is 3.9 persons per family

3) Living Conditions

Major indicators of living conditions and industrial aspects described in the table below show that the area is a typical rural area in Cambodia. The families have no electricity, little access to latrines, boreholes are the source of water use and the families mainly make a living from agriculture.

4) Transportation

The bridge is located in the rural area of Chantrea district. It takes about 50 minutes to the provincial town. Mini-buses, motorbikes, and cars are widely used and are the common transportation means for local people.

## **9.3 Legal and Institutional Frameworks of Environmental and Social Considerations**

### **9.3.1 Legal Framework**

The environmental law is “Law on Environmental Protection and Natural Resources Management 1996” which stipulates “An environmental impacts assessment shall be carried out on every project and activity, both private and public, and shall be examined and evaluated by the Ministry of Environment before it is submitted to the Cambodia for decision” in Article 6.

A detailed procedure of environmental impact assessment is prescribed in “Sub-decree on Environmental Impact Assessment Process, 1999” and “Declaration on General Guideline for Conducting Initial and Full Environmental Impact Assessment Reports, 2009”

Laws, decrees, sub-decrees and regulations related to environmental and social considerations published in Cambodia are as follows.

- 1) Constitution:
  - a) Article 59 of the Constitution, 1993 (GOC)
- 2) General Law:
  - a) Law on Environmental Protection and Natural Resources Management, 1996 (MOE)
  - b) Protected Area Law, 2008 (MOE)
  - c) Law on Forestry, 2002 (MAFF)
  - d) Law on Fisheries, 2006 (MAFF)
  - e) Law on Water Resource Management, 2007 (MOE)
- 3) Environmental Standard:
  - a) Sub-decree on Water Pollution Control, 1999 (MOE)
  - b) Sub-decree on Air Pollution Control and Noise Disturbance, 2000 (MOE)
- 4) Environmental Impact Assessment:
  - a) Sub-decree on Environmental Impact Assessment Process, 1999 (MOE)
  - b) Prakas (Declaration) on Guideline for Conducting Environmental Impact Assessment Report, 2000 (MOE)
  - c) Sub-decree on the Organization and Functions of the Ministry of Environment, 1997 (MOE)
  - d) Declaration on General Guideline for Conducting Initial and Full Environmental Impact Assessment Reports, 2009 (MOE)
- 5) Land Acquisition and Resettlement:
  - a) Civil Code, 2007 (MOJ)
  - b) Land Law, 2001 (MOL)
  - c) Prakas on Collection of Tax on Unused Land, 1996 (MEF)
  - d) Expropriation Law, 2010 (MEF)

- e) Sub-decree on Social Land Concessions, 2003 (MLMUPC)
  - f) Sub-decree on Economic Land Concessions, 2003 (MAFF)
  - g) Compensation Price List of Affected Property, 2000 (MEF)
  - h) Sechkdey Prakas No. 6, Measures to Crack Down on Anarchic Land Grabbing and Encroachment, 1999 (GOC)
  - i) Letter No. 961 regarding the Implementation of Right of Way Policy on National Roads, Provincial Roads, Communal Roads and Railways in Cambodia, 2000 (MEF)
  - j) Circular on Settlement of the illegal construction on the state land in cities and urban areas, 2010 (GOC)
  - k) Sub-decree on Right of Way of National Road Channels and Railroads of the Kingdom of Cambodia, 2009 (GOC)
- 6) Others:
- a) Sub-decree on Solid Waste Management, 1999 (MOE)

### **9.3.2 Institutional Framework**

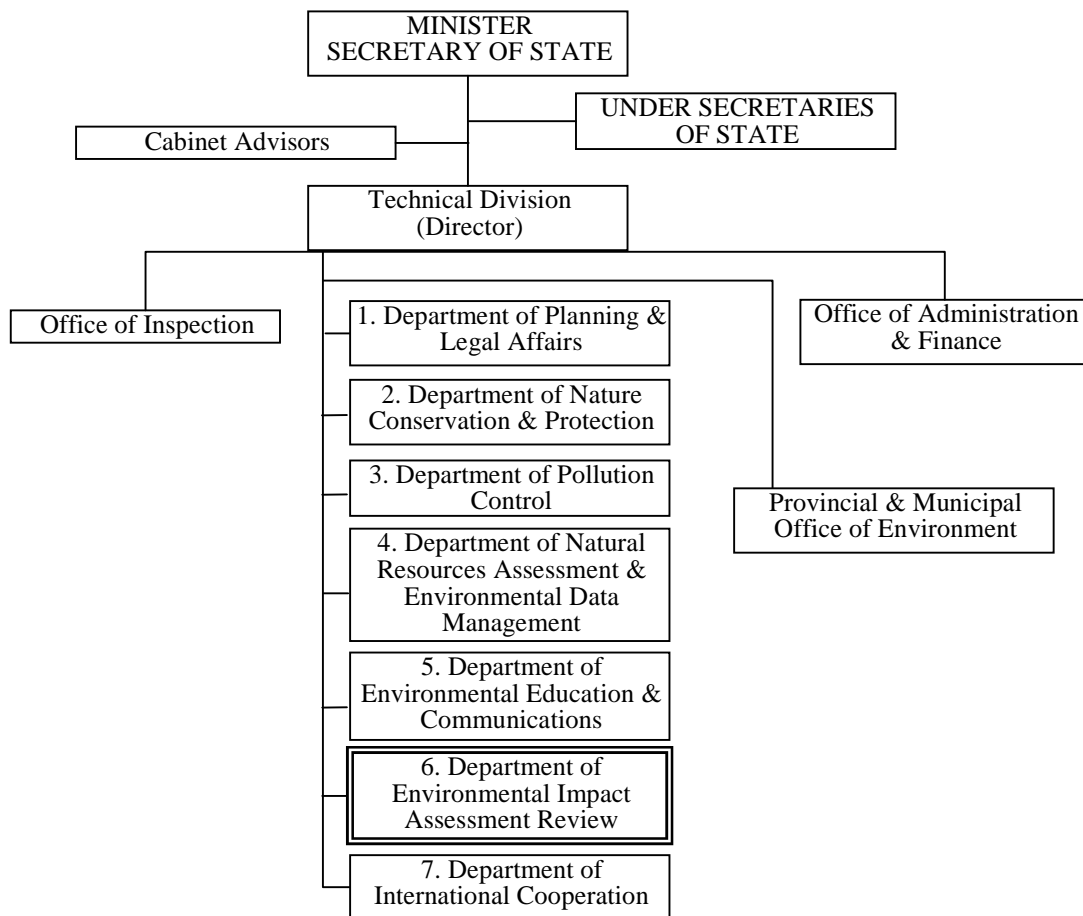
#### **(1) Ministry of Environment (MOE)**

Ministry of Environment (MOE) is in charge of environmental administration in Cambodia. It has seven departments in the head office as follows. The other 24 subordinate sections are established in provinces and the special city.

- 1) Environmental Law (including Climate change)
- 2) Natural Resources and Conservation
- 3) Pollution Control
- 4) Geographic Information System (GIS)
- 5) Environmental Education
- 6) Environmental Impact Assessment (EIA)
- 7) International Cooperation

In the MOE, the Department of Environmental Impact Assessment Review, which has the following five sections, is in charge of environmental impact assessment. The Project Review Section is responsible for review of environmental impact assessment.

- 1) Project Review
- 2) Environmental Monitoring
- 3) Planning and Statistics
- 4) Administration
- 5) Conflict, Legislation, and International Cooperation



Source: JICA Preparatory Study for “The Study on the Outer Ring Road of Phnom Penh Metropolitan Area in the Kingdom of Cambodia”

**Figure 9-3 Organization Chart of MOE**

**(2) Other Agencies for Environmental Administration**

Other major agencies for environmental administration are as follows.

- 1) Ministry of Agriculture, Forestry and Fisheries (MAFF): irrigation water supply, hydrological monitoring, forestry and fishery management, pesticide and fertilizer management
- 2) Ministry of Industry, Mines and Energy (MIME): licensing for industrial construction, water supply for urban areas, licensing for mining concession, hydropower plant management,
- 3) Local Government: licensing for building permission, solid waste disposal management, wastewater management

**(3) Institution for Land Acquisition and Resettlement**

Inter-ministerial Resettlement Committee (IRC), which crosses over ministries, was originally set up in 1998 upon a requirement for ADB project implementation in MEF. The IRC was setup by project base to coordinate resettlement compensation and make payments.

Recently, the Resettlement Department (RD) was established in the MEF for policy making and coordination among organizations on land acquisition and involuntary resettlement caused by public projects. The RD has respective sections for land acquisition and involuntary resettlement according to project fund, which are responsible for bilateral projects between Japan and others, multilateral projects (ADB, WB) and government projects. The RD is also in charge of the secretariat of IRC.

**9.3.3 EIA Procedure**

**(1) EIA Procedure**

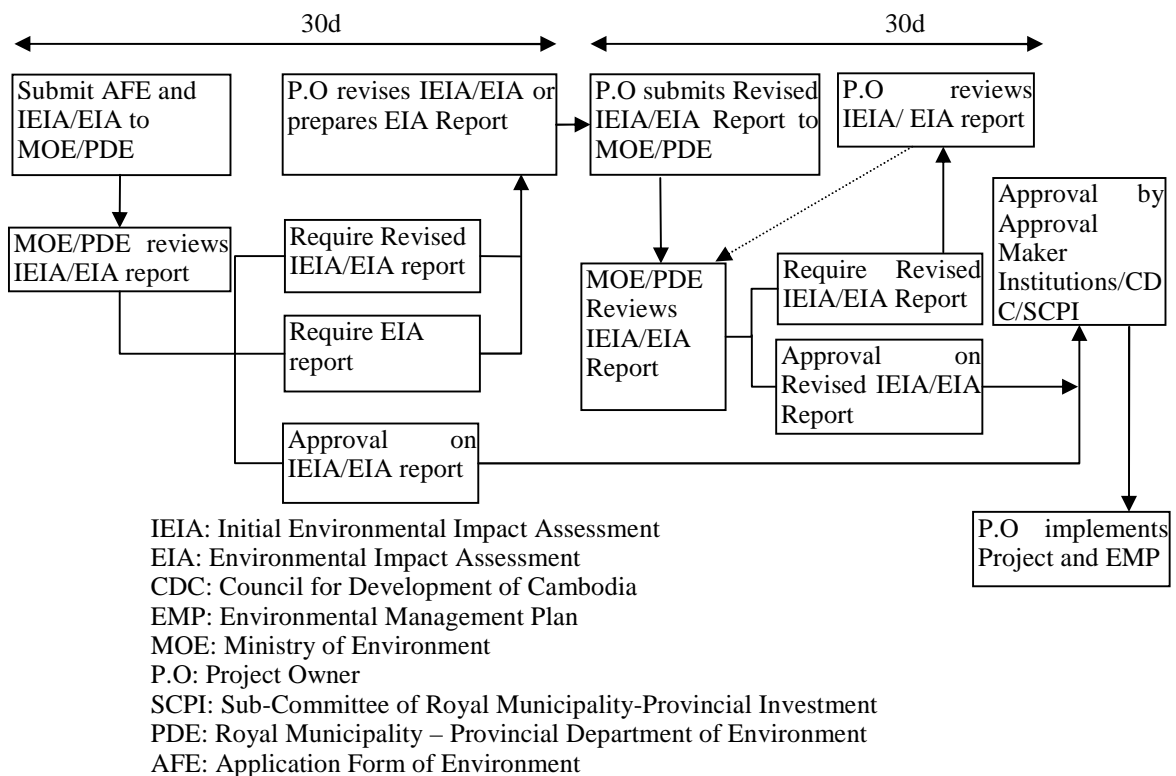
“General Guideline for Conducting Initial EIA and Full EIA Report, 2009” is the latest guideline of EIA procedure in Cambodia. The general procedure is summarized as the following process and in Figure 9-4 according to the guideline. EIA is required for proposed projects where significant impacts are expected. In the case where expected impacts are not significant, an IEIA (Initial Environmental Impact Assessment equivalent to IEE) is required for the proposed projects.

A project proponent conducts an IEIA study, prepares an IEIA report and submits it with an Application Form of Environment (AFE) to MOE or Royal Municipality - Provincial Department of Environment (PDE) for screening and review. If those agencies (MOE or PDE) evaluate that the IEIA report contains appropriate contents for environmental and social consideration, the IEIA report is approved for the project implementation or the agencies give the proponent some comments to revise the IEIA report. If the agencies evaluate that the (full) EIA is necessary for the proposed project, the proponent studies EIA, prepares EIA report and submits it to the agencies. The agencies evaluate it and approve it or give comments for the review.

The project proponent can use a consultant company to study IEIA or EIA and prepare report. The consultant company should be registered in the Ministry of Commerce and recognized by MOE.

- 1) Project owners prepare an IEIA or Full EIA report for proposed project
- 2) Project owners submit an Application Form of Environment (AFE) and IEIA or EIA report to MOE or Royal Municipality - Provincial Department of Environment (PDE)
- 3) Department of Environmental Impact Assessment Monitoring and Review (DEIAMR) in MOE or PDE reviews IEIA/EIA report
- 4) DEIAMR or PDE visits a project sites and evaluate the IEIA or EIA report

- 5) DEIAMR or PDE do screening whether the IEIA or EIA is required for the proposed project
- 6) DEIAMR or PDE review and provide comments on the IEIA or EIA report
- 7) MOE or PDE prepare the official letter for approval or require revision of the IEIA or EIA report
- 8) DEIAMR or PDE monitor that project owner will follow the Environmental Management Plan (EMP) during project implementation, operation and closure as stated in the IEIA or EIA report



Source: Declaration on General Guideline for Conducting Initial and Full Environmental Impact Assessment Reports

**Figure 9-4 Procedure of Environmental Approval**

**(2) EIA Screening**

In Cambodia, “Law on Environmental Protection and Natural Resources Management” stipulates that every project shall enclose a preliminary Environmental Impact Assessment or Environmental Impact Assessment in Article 7.

The List of the Projects that Require an EIA in Annex of Sub-Decree No 72 ANRK. BK. of “Sub-decree on Environmental Impact Assessment Process” describes type and activities of the projects with the project size and capacity. In case of bridge construction, EIA is required for a project which is equal to or more than 30 tons in weight of design load.

Besides, the Article 44/Chapter VIII of Protected Area Law 2008 stipulates that an Environmental and Social Assessment shall be required on all proposals and investment for development within or adjacent to protected area boundary to minimize adverse impacts on the environment and to ensure that management objectives of protected areas are satisfied.

A Pre-F/S or F/S is attached to an EIA report, consequently, neither IEIA nor EIA is required for the Study because the Study aims at neither Pre-F/S nor F/S. Regarding further steps for the project implementation, a prospect of MOE is that an IEIA is appropriate for the bridge replacement although the submitted IEIA report is evaluated for a requirement of EIA, revision of IEIA report or approval.

## **9.4 Scoping and TOR of Environmental and Social Study**

### **9.4.1 The Purpose of Environmental and Social Study**

The work items of Environmental and Social Study for the Package A are as follows.

- 1) Confirmation of the environmental and social considerations system in Cambodia
- 2) Collection of the baseline information
- 3) Site survey and scoping on the prioritized roads and bridges
- 4) Estimate and assess the environmental and social impact from the Project.
- 5) Propose the mitigation measures
- 6) Disclose the information to the organization concerned.

Since the bridges on roads connecting the Southern Economic Corridor are supposed to be important, scoping of these roads and bridges will be carried out in the early stage of the study. Especially for the items 2), 3), 4) and 5), an environmental and social survey will be implemented with a sub-contract of a local consultant because the number of the bridges to be replaced can be many and those locations can disperse widely.

The Project is categorized as “Category B” because it does not exert serious impacts on the environment and social situations and the study is required at Initial Environmental Evaluation (IEE) level in accordance with JICA guideline of April 2004.

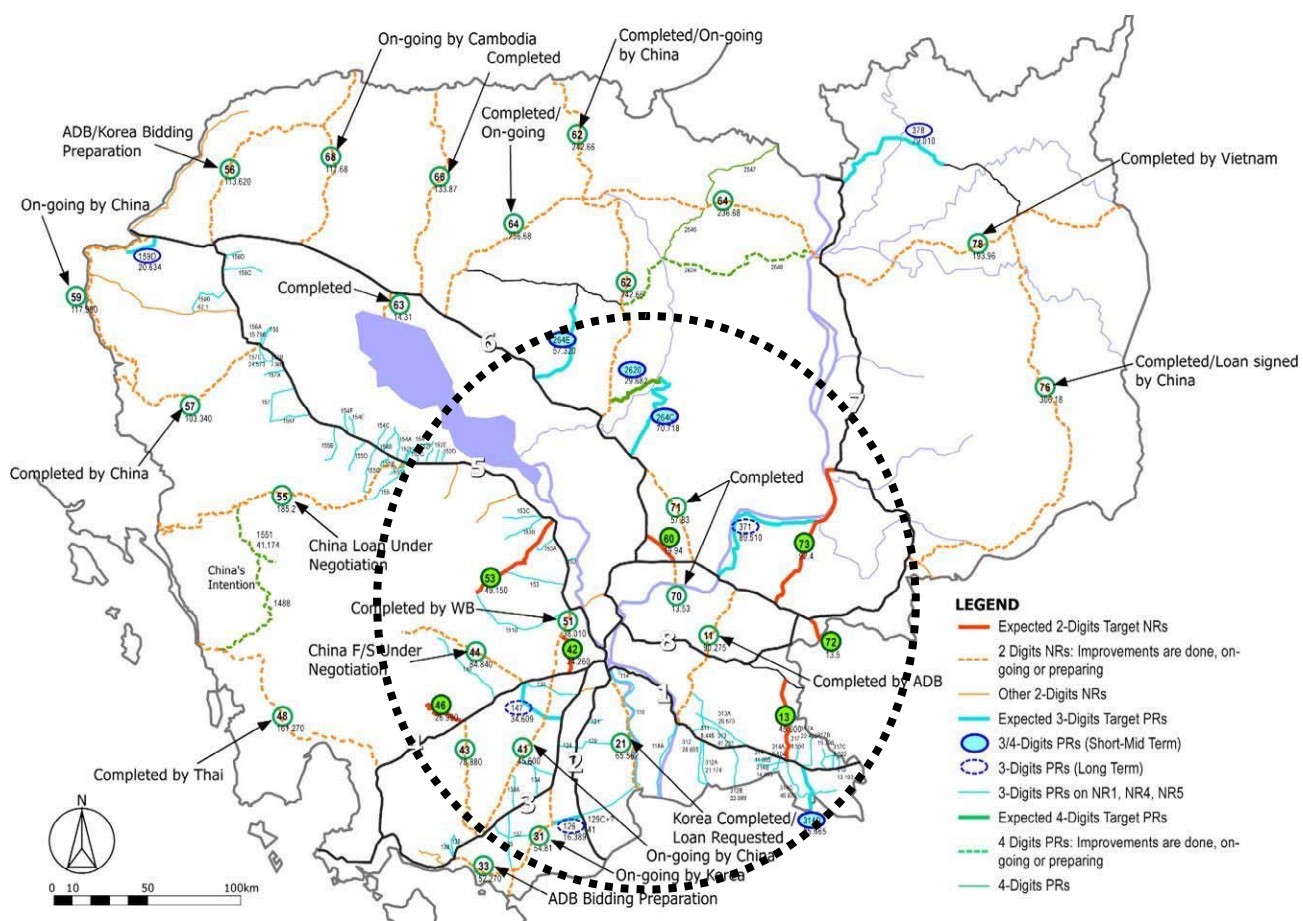
Besides, the Project is not for Feasibility Study and the Environmental and Social Study does not directly support implementation of IEIA or EIA in Cambodian environmental impact assessment procedure. Therefore, the survey with a sub-contract of a local consultant will be conducted for preparing information and study including items 2)-5) mentioned above at IEE level in order to promptly conduct IEIA or EIA toward implementation of the bridge replacement project.

## 9.4.2 Preliminary Scoping

### (1) Preliminary Selection of the Target Roads for the Preliminary Scoping

The bridge inventory survey and traffic count survey were conducted for the prioritization; however, those surveys needed time to obtain their outcomes. Therefore, the target roads were selected for the preliminary scoping based on the following points of view.

- 1) Exclude 2-digit roads on which surface and bridges have already been improved, the improvement is on-going or other donors have intentions based on 1) the list of Project Profile & Progress provided by the MPWT, 2) opinions in the first counterpart meeting, and 3) site reconnaissance by the Study Team.
- 2) 2-digit roads which were recommended for the short or medium-term projects in the “Follow-up Study on the Road Network Development Master Plan 2009”.



Source: Study Team

**Figure 9-5 Preliminary Target Roads for the Preliminary Scoping**



**(2) Preliminary Scoping**

The Study Team conducted site reconnaissance and did a preliminary scoping based on the following policies to plan further Environmental and Social Study.

- 1) Target roads: 2-digit roads expected for the priority of the roads shown in Figure 9-5.
- 2) Surveyed roads: NR60, NR42, NR13, NR72, NR73, NR53, NR46 and PR314D (This 3- road was also surveyed as connecting NR1 and a border gate of Vietnam.)
- 3) Expected types of bridges to be replaced: Bailey bridge, wooden bridge, steel bridge (actually depending on degree of deterioration and year of construction)
- 4) Expected bridges to be replaced were surveyed and results were collectively evaluated as the preliminary scoping.
- 5) Major characteristics of environmental conditions around the surveyed bridges depended on length of the bridges, the locations on a river, on a flood plain (on a way of water transmission in flood, there is no water flow in dry season), or on a river in mountainous area.
- 6) The expected project activity is replacement of the existing bridges, therefore, basically it does not significantly change the existing environmental and social conditions.
- 7) As the process of replacement is construction of diversion, construction of temporary bridge, demolition and clearance of the existing bridge, most likely negative impacts are expected in the construction phase.
- 8) However, as the Package A aims at prioritization of the bridges to be replaced and the Study does not include construction method and implementation schedule, consequently the locations of temporary bridges and diversions (closer places are required) are still unclear.
- 9) Therefore, the area within ROW (25m each side from the road centre in 2-digit roads) is assumed as the construction area.
- 10) In the process of replacing the bridges, there are some structures within the ROW and temporary relocation or involuntary resettlement will occur to secure the space of diversions and replacement works (e.g. NR73).

### 9.4.2.2 Draft TOR of Environmental and Social Study

A draft TOR of further Environmental and Social Study is summarized in based on the results of preliminary scoping.

**Table 9-1 Draft TOR of Environmental and Social Study**

No.	Likely Impacts	Phase/ Rating	Study Item	Study Method	
Social Environment:	1	Involuntary Resettlement	Pre-constr. B-	<ul style="list-style-type: none"> <li>Scale of potential area, buildings or households for temporary relocation or involuntary resettlement</li> <li>Policy of resettlement</li> </ul>	<ul style="list-style-type: none"> <li>Collection of relevant legislations</li> <li>Site reconnaissance for the numbers of buildings, locations, households, types</li> <li>Site reconnaissance for land use</li> </ul>
	2	The poor people	Pre-constr. C-	<ul style="list-style-type: none"> <li>Existence of poor people nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing to the residents nearby the bridges and local government</li> </ul>
	3	The indigenous and ethnic people	Pre-constr. C-	<ul style="list-style-type: none"> <li>Existence of ethnic minority nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing to the residents nearby the bridges and local government</li> </ul>
	4	Local economy such as employment and livelihood, etc.	Constr. B+/- Operation B+	<ul style="list-style-type: none"> <li>Socio-economic situations of District, Commune, or Village, which includes the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Study on existing information (literature survey)</li> <li>Site reconnaissance</li> <li>Hearing for District, Commune, or Village Offices</li> <li>Hearing for nearby residents</li> </ul>
	5	Land use and utilization of local resources	Constr. B-	<ul style="list-style-type: none"> <li>Land use situations nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance for land use</li> </ul>
	6	Water Usage or Water Rights and Rights of Common	Constr. B-	<ul style="list-style-type: none"> <li>Situations of water use and fishery in the rivers nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing for District, Commune, or Village Offices</li> <li>Hearing for nearby residents</li> </ul>
	7	Existing social infrastructures and services	Constr. B- Operation C+	<ul style="list-style-type: none"> <li>Infrastructure on the bridges and approach roads</li> <li>Public facilities around the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing for District, Commune, or Village Offices</li> <li>Hearing for nearby residents</li> <li>Hearing for public facilities (clinics, schools)</li> </ul>
	11	Cultural heritage	Constr. B-	<ul style="list-style-type: none"> <li>Temples, monuments nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing for nearby residents</li> </ul>
	15	Hazards (Risk), Infectious diseases such as HIV/AIDS	Constr. B-	<ul style="list-style-type: none"> <li>Situations of diseases including HIV/AIDS around the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Study on existing information (literature survey)</li> <li>Hearing for relevant organizations</li> <li>Hearing for District, Commune, or Village Offices</li> </ul>
	16	Working conditions	Constr. B-	<ul style="list-style-type: none"> <li>Policy and measures for working security</li> </ul>	<ul style="list-style-type: none"> <li>Study on labour standards</li> <li>Study case examples of contracts regarding working conditions</li> </ul>
Natural Environment	17	Protected Areas	Constr. C-	<ul style="list-style-type: none"> <li>Existence of protected areas nearby the bridges</li> </ul>	<ul style="list-style-type: none"> <li>Study on the existing information (literature survey)</li> <li>Hearing and data collection for/from relevant organizations (MOE, MAFF)</li> <li>Site reconnaissance</li> </ul>
	18	Flora, Fauna and Biodiversity	Constr. B-	<ul style="list-style-type: none"> <li>Types of flora and fauna around the bridges</li> <li>Existence of indigenous and endangered species</li> </ul>	<ul style="list-style-type: none"> <li>Study on the existing information (literature survey)</li> <li>Hearing and data collection for/from relevant organizations (MOE, MAFF)</li> <li>Site reconnaissance</li> <li>Hearing for nearby residents</li> </ul>

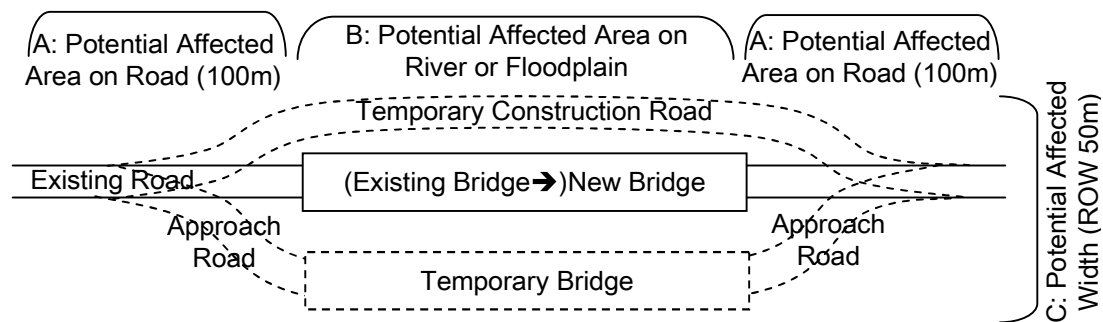
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No.	Likely Impacts	Phase/ Rating	Study Item	Study Method	
	19	Hydrological Situation	Constr. C-	<ul style="list-style-type: none"> <li>Situations of seasonal water flow (directions, water levels)</li> </ul>	<ul style="list-style-type: none"> <li>Site reconnaissance</li> <li>Hearing for nearby residents</li> </ul>
	21	Soil Erosion	Constr. B-	<ul style="list-style-type: none"> <li>Methods of slope surface by cut and fill</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> </ul>
Pollution	24	Air Pollution	Constr. B-	<ul style="list-style-type: none"> <li>Preventive measures for exhaust gases/dust from construction vehicle and equipment</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> </ul>
	25	Water Pollution	Constr. B-	<ul style="list-style-type: none"> <li>Methods of slope surface by cut and fill</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> </ul>
	26	Waste	Constr. B-	<ul style="list-style-type: none"> <li>Disposal solutions for construction waste including demolished bailey bridges</li> </ul>	<ul style="list-style-type: none"> <li>Hearing for relevant organization (MPWT)</li> </ul>
	27	Soil Contamination	Constr. B-	<ul style="list-style-type: none"> <li>Preventive measures for leaks of fuel/oil from construction vehicle and equipment</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> </ul>
	28	Noise and Vibration	Constr. B- Operation C+	<ul style="list-style-type: none"> <li>Preventive measures for noise/vibration from construction vehicle and equipment</li> <li>Noise from the existing bailey bridges</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> <li>Hearing for nearby residents</li> </ul>
	30	Offensive Odor	Constr. C-	<ul style="list-style-type: none"> <li>Preventive measures for odor from construction vehicle and equipment</li> </ul>	<ul style="list-style-type: none"> <li>Study description of works, construction methods, period, types of machinery</li> </ul>
Others	32	Accidents	Constr. B- Operation B-	<ul style="list-style-type: none"> <li>Accidents during construction works on labours and residents</li> <li>Traffic accidents after the replacement of bridges around them</li> </ul>	<ul style="list-style-type: none"> <li>Hearing for contractors</li> <li>Hearing for residents nearby some bridges replaced before</li> </ul>

Source: Study Team

## 9.5 Results of the Study

Results of the detailed Environmental and Social Study for each prioritized bridge are reported in the Environmental and Social Profiles attached in Appendix E. The study area is specified as shown in Figure 9-6 below according to Chapter 6.4 Construction Plan. An area within ROW which is designated as 25 metres each side from the road centre in 2-digit roads is assumed for a Potential Affected Area (hereinafter referred to as PAA) from the construction works. The site survey of Environmental and Social Study was conducted in the PAAs mainly with observation and interviews for the residents. 47 bridges are located in flat plain or gentle hill areas and more than half of them have annual river water flows below the bridges.



Source: Study Team

**Figure 9-6 Potential Affected Area around the Prioritized Bridges**

### 9.5.1 Involuntary Resettlement

Major buildings and population in the PAAs were identified through the site survey. Population and number of households in the PAAs were estimated with the results of questionnaire survey for the residents in the PAAs. Total 120 households were interviewed in the survey. The PAAs which have populations over 100 are bridge numbers 70-2, 73-4, 279-7, and 377-1/2/5/7. Those are located on the roads along the Mekong except 70-2. Especially, PR377 located north of Kratie Town is densely populated.

### 9.5.2 Impoverished People

Wooden walls with tiled roofs and zinc roofs dominate the building structures in the PAAs. Most interviewed families owned the buildings and land, and some families rented the buildings and land. The families mainly use city power and batteries as the source of light. However, few families use pipe water for drinking water. Firewood is the source of cooking fuel for them. About 70% households have no toilet in premises. These living conditions appear like a typical rural area in Cambodia.

However, based on average monthly household incomes heard in the interviews, households under WB poverty line (daily US\$ 1.25 per capita) were found in each PAA

where some residents were identified. However, the answers were still unclear since not all household heads were interviewed due to their unavailability and limited survey time. Project Affected Persons (PAPs) will be identified in further study, Detailed Measurement Survey (DMS) will be conducted, and monthly incomes will be also surveyed.

### **9.5.3 The indigenous and ethnic people**

Based on the interviews to the households, no indigenous and ethnic people were identified around the bridge. Ethnicities of all interviewees who live around the bridges were Khmer and they had Cambodian nationality.

### **9.5.4 Local Economy such as Employment and Livelihood, etc.**

#### **(1) Major Income Sources of Local People**

Most households have major income sources from self-employment (shops) and farming (rice, potato, cassava, corn, rubber). Other income sources are permanent employed government officers, fishing and motorcycle taxi driver although these are few.

#### **(2) Expected Construction Workers**

In case of bridge replacement works for 30 metre length, the following construction workers are assumed for each type of work.

- 1) Superstructure work: bridge chief, special worker, reinforcement workers (3), formwork workers (3), general workers (5-10), truck crane driver
- 2) Base structure work: general chief, reinforcement workers (3), formwork workers (3), steeplejack (3), general workers (5-10), truck crane driver
- 3) Foundation work: general chief, steeplejack (3), special worker, general workers (5-10), reinforcement workers (3), concrete workers (3), diesel pile hammer driver, backhoe driver
- 4) Road work: general chief, special worker, general workers (5-10), Asphalt finisher driver, road roller driver, tire roller driver

### **9.5.5 Land use and Utilization of Local Resources**

Major land uses in the PAAs were dominated by residential land, farmland, shrub land and grassland.

### **9.5.6 Water Usage or Water Rights and Rights of Common**

Annual river water and seasonal surface water nearby the bridges are used by local people especially for washing, cleaning of equipment/farming gears/motor cycles, bathing or fishing.

### **9.5.7 Existing Social Infrastructures and Services**

Telephone cables and electric cables are installed with poles around most of the bridges. Water supply pipes are also laid on several bridges and even optical cables are laid on a few bridges. A few schools, police and guard posts or rest halls observed in the PAAs of the bridge numbers: 279-7, 372A-3, 314C-1, 314D-1, 316A-1.

### **9.5.8 Cultural Heritage**

Specific cultural heritages were not identified nearby the bridges. However, two pagodas were observed in two PAAs. One was near bridge number 73-8 and the other was near bridge number 372A-3.

### **9.5.9 Hazards (Risk), Infectious Diseases such as HIV/AIDS**

Most local diseases expressed by interviewees of local people living around the bridges are common cold, while Dengue fever, diarrhea and malaria are rare. Information on HIV/AIDS was not available from local health centers.

### **9.5.10 Working Conditions**

In Cambodia, Articles 229 and 230 of the Labour Law stipulate on the health and safety of workers as follows. The construction workers for the replacement works of the bridges are safeguarded by the law. Besides, contract of the bridge replacement works requires contractors a safety plan and an environmental management plan.

- 1) Article 229: All establishments and work places must always be kept clean and must maintain standards of hygiene and sanitation or generally must maintain the working conditions necessary for the health of the workers.
- 2) Article 230: All establishments and work places must be set up to guarantee the safety of workers. Machinery, mechanisms, transmission apparatus, tools, equipment and machines must be installed and maintained in the safest possible condition. Management of technical work utilizing tools, equipment, machines, or products used must be organized properly for guaranteeing the safety of workers.

### **9.5.11 Protected Areas**

Protected areas are not located around the bridges.

### **9.5.12 Flora, Fauna and Biodiversity**

#### **(1) Flora**

Local surveyors visually checked flora around the bridges. Those typical flora are fruit trees (papaya, mango, banana, tamarind, jack fruit, guava), palm tree, coconut tree, kapok tree, makak tree, areca palm tree, rain tree, jujube tree, bamboo, eucalyptus and so on. They

are common flora in Cambodia. However, the survey results included an EN (endangered) species name as follows. There were five rosewood trees in the residential land and those owners planted the trees about five years ago.

**(2) Fauna**

On the other hand, faunas was surveyed by interviewing local people while showing species lists with small pictures attached, and surveyors asked them whether they have seen these species around bridges. Therefore, many people indicated birds, mammals, reptiles, amphibians and fishes on their memories without limitation of time period and frequency. Most species answered were common species in Cambodia although the results included a few EN (endangered) species names as follows.

Bridge No.	Type	Local name	English name	Scientific name
373B-1	Fish	Trey Lolok sor	Yellow Tail Brook Barb	Poropuntius deauratus
375-2	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata
375-3	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata
	Mammal	Svakrorvat	Black-shanked Langur	Pygathrixnemaus
375-4	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata
314C-1	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata
	Fish	Trey Lolok sor	Yellow Tail Brook Barb	Poropuntius deauratus
314D-1	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata
316A-1	Reptile	Andoeukphnom/Prech/Dambouk	Elongated Tortoise	Indotestudoelongata

Regarding Black-shanked Douc Langur (a type of monkey) at 375-3, the habitat is in Seima Protected Forest according to the Wildlife Conservation Society (WCS) which supports Cambodian wildlife conservation. Seima Protected Forest is located in eastern Cambodia bordering Vietnam. The nearest boundary of the Forest (a buffer area) is located on NR7 about 35kilometres away from 375-3.

**9.5.13 Hydrological Situation**

The bridges are installed not only over rivers but also at flood plains to transmit flood water from the Mekong, with gentle velocity.

#### **9.5.14 Soil Erosion**

##### **(1) The Existing Conditions**

The most common soil type around the bridges is laterite. Local people recognized little erosion although fair erosion (small concavities) was observed in the site survey.

##### **(2) Assumed Bridge Replacement Works**

The bridge replacement works can cause soil erosion from slope surface by cut and fill at least temporarily in construction period. Typical works are described as follows.

###### 1) Bridge replacement Conditions

- a) Superstructure type: RCDG (reinforcement concrete deck girder)
- b) Pier type: wall type pier, concrete driven pile
- c) Bridge abutment type: reversed T-type abutment, concrete driven pile
- d) Main girder construction method: by truck crane
- e) Diversion type to cross river: temporary bridge, H-steel sheet pile
- f) River diversion method: temporary diversion canal

###### 2) Work schedule (about 16 months for 30m length)

- a) Site office installation work (1 month)
- b) Preparation work: diversion construction, temporary bridge construction, removal work (2 months)
- c) Foundation work (1.5 months)
- d) Base structure work (5 months)
- e) Superstructure work and Road work: main girder work, bridge surface work (5 months)
- f) Cleaning work (1 month)

#### **9.5.15 Air Pollution**

##### **(1) Existing Air Conditions**

The existing sources of air pollution around the bridges were not identified in the survey. The local interviewees said the air quality was good condition except the residents of bridge number 373D-3. They answered it was bad in dry season due to dust generated by local transportation on unpaved road.

##### **(2) Assumed Vehicles and Machinery for Construction Works**

In the bridge replacement work period, exhaust gases and dust generated by the construction vehicles and machinery can be the sources of air pollution. However the construction period is short and type of construction equipment is small for the bridge replacement so that the influence to the environment at construction site will minimum.



#### **9.5.16 Water Pollution**

The existing sources of water pollution around the bridges were not heard from the local interviewees. The soil erosion from the slope surface by cut and fill can degrade river water quality at least temporarily in construction period.

#### **9.5.17 Waste**

Local municipalities of rural areas in Cambodia generally do not have solid waste disposal systems. Therefore, contractors have to treat solid waste by themselves. Typical treatment method is to bury the solid waste in coordination with surrounding communities. Waste water is treated with septic tank as usual.

#### **9.5.18 Soil Contamination**

In the bridge replacement work period, unintentional considerable spilled fuel and oil from the construction vehicles and machinery can be the sources of soil contamination.

#### **9.5.19 Noise and Vibration**

The local people who live nearby the bridges recognize some or much noise and vibration especially from the bailey bridges while vehicle passing by. The bridges that noise and vibration were identified were bridge numbers 70-1/2, 73-4/8/16, 372A-1/2/3/4/5, 377-2/5, 314D-1. Major source of noise are steel deck of Bailey bridge and they will be improved after bridge replacement with permanent bridges.

#### **9.5.20 Offensive Odour**

The local residents did not recognize offensive odor nearby the bridges. The sources of offensive odor were not identified in the survey. In the bridge replacement work period, exhaust gases and dust generated by the construction vehicles and machinery, domestic water and wastes from site offices can be the sources of offensive odor. Types of the machinery for the bridge replacement work are assumed

#### **9.5.21 Accidents**

Typical possible accidents involving construction workers during the removal and construction works of bridges are falls, accidents by the construction vehicles and machinery. Residents around the construction sites can be involved in traffic accidents. The Labor Law requires the worker's health and safety, and contract of the bridge replacement works requires contractors to compile a safety plan and environmental management plan. The safety plan consists of safety manual and safety working practices, which include safety meeting/reporting, personal protective equipment, access control, obligations and cares of the works.

Other accident cases and traffic accidents after the construction have been increased around the new bridges according to the interviews to local people who live nearby replaced bridges. They recognized traffic accidents increased after bridge replacements.

## **9.6 Evaluation of Anticipated Environmental and Social Impacts**

The results of evaluation show that the most important adverse impact is “Involuntary Resettlement“. The results of evaluations by route where the bridges are located are described in the following section.

### **9.6.1 Bridge Nos. 11-2/3 on NR11**

No serious adverse impacts are expected for bridge number 11-2/3. No buildings and resident were identified around the both of bridge number 11-2/3. Major land use was rice field around the bridges. There were seasonal surface water flows (flood water) from the Mekong in rainy season.

### **9.6.2 Bridge No. 70-1/2 on NR70**

The most important adverse impact is “Involuntary Resettlement“ especially around the bridge number 70-2. Houses and shops (or mixtures of these) are densely built in the PAA of bridge number 70-2. Some part of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. There are annual river water flows under the bridges and these can be affected by the diversions to cross the rivers.

### **9.6.3 Bridge Nos. 73-4/5/6/7/8/16 on NR73**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridge number 73-4/8/16. Houses and shops/restaurants (mixtures of these) are built especially in the PAAs of bridge number 73-4/8. A pagoda was identified around bridge number 73-8 and its walls and a garden are in the PAA. Some part of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. The bridge numbers 73-8/16 are located close to the Mekong and their annual river flows can be affected by the diversions to cross the rivers.

### **9.6.4 Bridge Nos. 277-3/4 on PR277**

No serious adverse impacts are expected for bridge numbers 277-3/4. No buildings and resident are identified around both bridges. Major land use is rice field around the bridges. There are seasonal surface water flows in rainy season.

**9.6.5 Bridge Nos. 279-7 on PR279**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridge number 279-7. A workshop, houses and shops (or mixtures of these) are built in the PAA. A police post and a rest hall are located on the north side of the bridge. Some part of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. The bridge is located close to the Mekong and the annual river flow can be affected by the diversions to cross the river.

**9.6.6 Bridge Nos. 372A-1/2/3/4/5 on PR372A**

The most important adverse impact is “Involuntary Resettlement“ nearby all bridges. Houses and shops (or mixtures of these) are built in the PAAs. A private English school, a pagoda and a guard post were located in the PAA of 372A-3. Major land uses are residential area and vegetable fields (cassava/rubber) around the bridges. Some part of them can be affected by the bridge replacement works depending on the locations of diversions, temporary bridges or material yards. There were seasonal surface water flows at 372A-1/2 and annual river water flows at 372A-3/4/5. They can be affected by the diversions to cross the rivers.

**9.6.7 Bridge Nos. 373B-1 on PR373B**

No serious adverse impacts are expected for bridge number 373B-1. No buildings and resident are identified around the bridge. The land use was dominated by grassland followed by rice field around the bridge. There is annual river water flow below the bridge and it can be affected by the diversion to cross the river.

**9.6.8 Bridge Nos. 373D-1/2/3/4/5/6/7/9/10/12 on PR373D**

The most important adverse impact is “Involuntary Resettlement “ nearby five bridges, 373D-1/3/5/7/12. Houses and shops (or mixtures of these) are built in the PAAs. A temporary rest place is located in the PAA of 373D-5. Major land uses are residential area and farmland (rice field) around the bridges. Some of them can be affected by the bridge replacement works depending on the locations of diversions, temporary bridges or material yards. However, no serious adverse impacts are expected for the other bridges because no buildings and residents are identified around the bridges. Major land uses are farmland (rice field), grassland and shrub land around the bridges. There are annual river water flows at the bridge numbers 373D-1/5/7/12. They can be affected by the diversions to cross the rivers.

**9.6.9 Bridge Nos. 375-2/3/4 on PR375**

The most important adverse impact is “Involuntary Resettlement“ nearby bridge number 375-3. Farmers’ houses are built in the PAA of bridge number 375-3. A temporary rest place

is located in the PAA of bridge number 373D-5. Major land uses are residential area, farmland (rice field) and shrub land around the bridges. Some part of them can be affected by the bridge replacement works depending on the location of diversion, temporary bridge or material yard. However, no serious adverse impacts are expected for the other bridges because no buildings and residents are identified around the bridges. Major land uses are farmland (rice field), grassland and shrub land around the bridges. There are seasonal surface water flows at the bridges in rainy season. They can be affected by the diversions to cross the rivers.

**9.6.10 Bridge Nos. 377-1/2/3/4/5/6/7/8/9/10/11/12 on PR377**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridges except bridge number 377-11. Houses and shops/restaurants (or mixtures of these) are built especially in the PAAs of bridge numbers 377-1/2/5/7. A guesthouse is identified on the north side of bridge number 377-2 and a workshop (car washing) was identified on the south side of bridge number 377-6. Major land uses are residential area, farmland (rice field) and shrub land around the bridges. Some part of them can be affected by the bridge replacement works depending on the locations of diversions, temporary bridges or material yards. The bridges are located close to the Mekong and their annual river flows can be affected by the diversions to cross the rivers.

**9.6.11 Bridge Nos. 314C-1 on PR314C**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridge number 314C-1. Houses and shops (or mixtures of these) are built in the PAA. A conference hall and a kindergarten were identified on the north side of the bridge. In the same site, there are stalls along both sides of the road. Major land uses around the bridge are public land, residential area and wetland in the PAA. Some of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. There is annual river water flow below the bridge and it can be affected by the diversions to cross the river.

**9.6.12 Bridge Nos. 314D-1 on PR314D**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridge number 314D-1. Houses and shops (or mixtures of these) are built in the PAA. A guard post is identified on the south side of the bridge. Major land uses around the bridge are residential area and wetland in the PAA. Some part of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. There is annual river water flow below the bridge and it can be affected by the diversions to cross the river.

### **9.6.13 Bridge Nos. 316A-1 on PR316A**

The most important adverse impact is “Involuntary Resettlement“ nearby the bridge number 316A-1. Houses and a workshop (or mixtures of these) are built in the PAA. A high school is identified on the north side of the bridge. Major land uses around the bridge are residential area, public land and wetland in the PAA. Some part of them can be affected by the bridge replacement works depending on the locations of diversion, temporary bridge or material yard. There is annual river water flow below the bridge and it can be affected by the diversion to cross the river.

## **9.7 Mitigation Measures**

In the pre-construction phase, land acquisition and resettlement are major adverse impacts from the Project. These will be basically mitigated in accordance with the Resettlement Action Plan (RAP) which will be prepared by MPWT with the assistance of consultants and the line agency, RD (MEF), in the feasibility study stage preferably or the designing stage at latest. On the other hand, adverse impacts on the natural environment and pollution are expected in the construction phase. The mitigation measures for them are incorporated into the Environmental Management Plan and Safety Plan as parts of the contract documents prepared with the engineering components of the Project.

## **9.8 Monitoring Plan**

In the PAAs of the bridges set-up for the Study, houses/commercial buildings are identified in the PAAs of 31 bridges and some of them can be affected by the bridge replacement works. Therefore, preparation of RAP and the land acquisition/resettlement activities are the most important monitoring items. Another important monitoring item is annual river water quality especially for the bridges located along the routes nearby the Mekong. Table 9-2 summarizes the proposed monitoring plan. However, the MOE may give some requests to be monitored on the IEIA report prepared and submitted for the Project implementation in the next step.

- 1) Major possible adverse impacts: land acquisition and resettlement, pollutions during the bride replacement works
- 2) Monitoring items considered by other bridge construction projects
- 3) Compliance with the Cambodian environmental standards

**Table 9-2 Proposed Monitoring Plan**

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
<b>Pre-construction Phase</b>				
Involuntary Resettlement	Preparation of RAP	Producers of RAP	During RAP preparation	MPWT/IRC/ Development Partners
	Entitlements of PAPs under the approved entitlement policies			
	Assessment of compensation under the agreed procedures			
	Public information, public consultation and grievance procedures as stated in the RAP	Project sites	During resettlement activities in the processes	
	Payment of compensation as stated in the RAP			
	Payment of compensation			
Functionality of Grievance Redress Mechanism				
<b>Construction Phase</b>				
Air Pollution	CO, NO2, SO2, O3, Lead, Total Suspended particulate	Construction site	At start of construction/ Every month	Supervising consultant/ Contractor
Water Pollution	pH, BOD5, Suspended Solid, Dissolved Oxygen, Oil content, Total Nitrogen, Total Phosphorus, Coliform	Upstream and Downstream of bridge	At start of construction/ Every month	
Noise	Noise level (dBa)	Nearby residential houses	At start of construction/ Every month	

Source: Study Team

## **9.9 Land Acquisition and Resettlement**

### **9.9.1 Necessity of Land Acquisition and Resettlement**

In the Study, as Package A aims at prioritization of the bridges to be replaced and the Study does not include design, construction method and implementation schedule, consequently the locations of temporary bridges and diversions are still unclear at the sites. According to the results of Study including Bridge Inspection Survey and Environmental and Social Study, structures and residents are identified in the PAAs and some of them can be affected by the bridge replacement works depending on the locations of diversions, temporary bridges and material yards.

### **9.9.2 Legal Framework**

#### **(1) Legislation**

Cambodian resettlement policy has been improved by implementation of international donor projects with JICA, ADB or WB according to requirements of their safeguard policies and compliance. The ADB has been supporting to prepare a sub-decree on the national resettlement policy, however, it has not been established yet. The Constitution and Land Law are still applied for resettlement as the basic laws.

**(2) Procedure of Land Acquisition and Resettlement Works**

Based on the public work experiences in Cambodia, 3 summarizes the land acquisition and resettlement work steps especially for international corporation projects although the procedures have not been legalized yet.

**Table 9-3 Land Acquisition and Resettlement Work Steps**

Resettlement Steps		Project Steps		
A. Pre-Resettlement Implementation Stage	<ul style="list-style-type: none"> <li>- Census (Number of Affected Persons, Socio-economic Survey)</li> <li>- Public Information Meeting</li> <li>- Resettlement Action Plan</li> </ul>	Feasibility Study (F/S)	Pre-Implementation	
(1) Resettlement Planning				
(2) Institutional Arrangements				
B. Resettlement Implementation Stage		<ul style="list-style-type: none"> <li>- Detailed Measurement Survey (Property Evaluation)</li> <li>- Replacement Cost Survey</li> <li>- Compensations Calculation</li> <li>- RAP Updating</li> <li>- Negotiation and Contract</li> <li>- Relocation Site Preparation</li> <li>- Payment and Relocation</li> </ul>		Approval
(3) Detailed Measurement Survey (DMS)				
(4) Replacement Cost Study (RCS)				
(5) RAP updating and Budgeting				
(6) Relocation Site Preparation	Design / Procurement			
(7) Negotiation and Contract				
(8) Budget Disbursement and Payment	<ul style="list-style-type: none"> <li>- Monitoring</li> <li>- Grievance Redress Mechanism</li> <li>- Income Restoration Program</li> </ul>	Construction	Resettlement Implementation	
C. Cross-Cutting Issues				
(9) Relocation				
(10) Public Consultation Meeting (PCM)				
(11) Grievance Redress Mechanism (GRM)	<ul style="list-style-type: none"> <li>- Monitoring</li> <li>- Grievance Redress Mechanism</li> <li>- Income Restoration Program</li> </ul>	Construction		
(12) Monitoring and Evaluation				

Source: MEF, MPWT, Study Team

**9.9.3 Scale of Land Acquisition and Resettlement**

As mentioned in section 9.9.1, the Study does not identify the scale of land acquisition and resettlement. Therefore, the Study Team conducted Environmental and Social Study (ESS) to investigate the conditions around the bridges. Some of them are affected by the bridge replacement works according to the locations of diversions, temporary bridges or material yards. In further studies, F/S or D/D, land acquisition and resettlement will be avoided where feasible, or minimized by alternative designs to reduce adverse impacts on the communities.

**9.9.4 Measures of Compensation and Supports**

As the Study does not include the designs and consequently does not identify the scale of land acquisition and resettlement, the measures of compensation and support are still unclear. Therefore, an entitlement matrix will be drafted to propose the policies of compensation and summarize the different types of impacts.

**Table 9-4 Draft Entitlement Matrix**

<b>Type of loss</b>	<b>Entitled Persons (Beneficiaries)</b>	<b>Entitlement (Compensation Package)</b>	<b>Implementation issues/Guidelines</b>	<b>Organization Responsible</b>
1. Loss of lands (residential and agricultural lands)	Legal owners of land identified by DMS	Cash Compensation at full replacement cost assessed by RCS under “Expropriation Law 2010”	<ul style="list-style-type: none"> <li>- Measurement of land demarcation by DMS</li> <li>- Assessment of replacement cost based on market value and other alternative measures by RCS</li> <li>- Full replacement cost may include market value (ex-transaction), administrative fees and taxes</li> </ul>	IRC/ MPWT
2. Loss of structures (residential and commercial structures)	Legal owners of structures identified by DMS	Cash Compensation at full replacement cost assessed by RCS under “Expropriation Law 2010”	<ul style="list-style-type: none"> <li>- Measurement of property by DMS</li> <li>- Assessment of replacement cost based on market value and other alternative measures by RCS</li> <li>- Full replacement cost may include material cost of building, labour cost, transport cost and administrative fees</li> </ul>	IRC/ MPWT
3. Loss of perennial trees and standing crops	Legal owners of the land or customarily recognized owners of trees and standing crops identified by DMS	Cash Compensation at full replacement cost assessed by RCS	<ul style="list-style-type: none"> <li>- Replacement cost is assessed by type, size, age, and productive values in RCS</li> </ul>	IRC/ MPWT
4. Loss of business due to dislocation	Owners of businesses identified by DMS	Disruption allowance for business owners on losses of business revenues during reestablishment period	<ul style="list-style-type: none"> <li>- Allowance is calculated in RCS</li> </ul>	IRC/ MPWT
5. Loss of income due to displacement	Household heads/ employees identified by DMS	Disruption allowance for households on income losses while reconstruction or repair of houses, and for employees on income losses during reestablishment period	<ul style="list-style-type: none"> <li>- Allowance is calculated in RCS</li> </ul>	IRC/ MPWT
6. Partial losses of community or public structures	Community or public structure representatives identified by the DMS	Rebuilding of partially lost structures (walls or gardens)	<ul style="list-style-type: none"> <li>- Coordination and negotiations with representatives of pagodas and schools</li> </ul>	IRC/ MPWT/ Supervising Consultant/ Contractor
7. Displacement of social infrastructure	Owners/operators of social infrastructure services identified by DMS	Temporary relocation of telephone and electric cables with poles, water supply pipes, optical cables and rehabilitations	<ul style="list-style-type: none"> <li>- Coordination and negotiations with owners/operators of social infrastructure services and communities</li> </ul>	IRC/ MPWT/ Supervising Consultant/ Contractor

Source: Study Team



### 9.9.5 Grievance Redress Mechanism

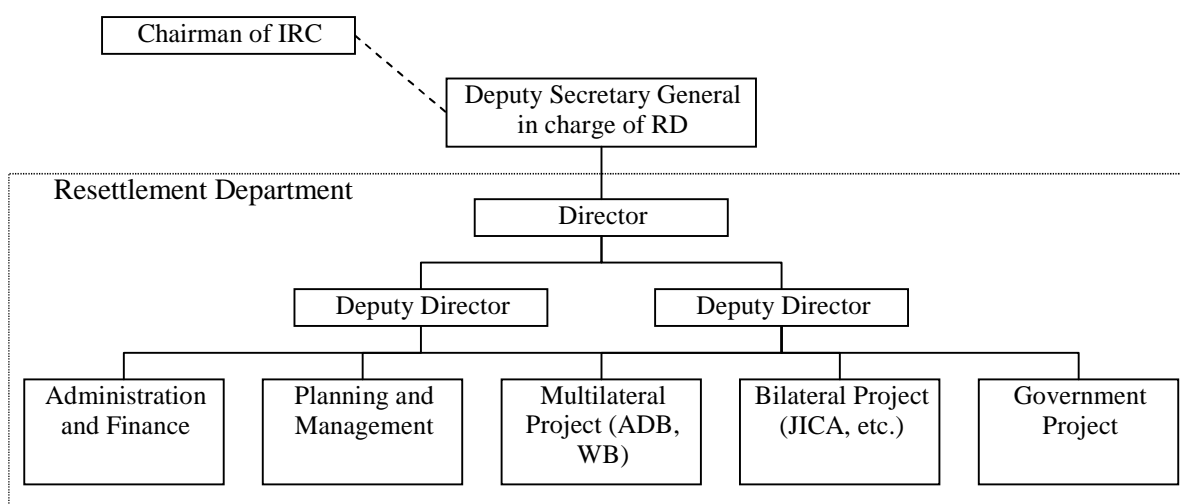
Grievance Redress Mechanism (GRM) in Cambodia is designed to settle complaints and grievances from PAPs in transparent and fair manner. Any PAPs can use the GRM free of costs. The grievances from PAPs will be handled with negotiations and mediations to obtain consent. The GRM consists of four stages as follows.

- 1st stage: PAPs submit grievances to PRSC-WG, IRC-WG or Commune/Sangkat
- 2nd stage: If the grievances are not settled at 1st stage, the grievances are brought to Districts/Khan Office (DO)
- 3rd stage: If the grievances are not settled at 2nd stage, the grievances are brought to Provincial/City Grievance Committee (PGC)
- 4th stage: If the grievances are not settled in administrative stages (1st-3rd stages), the grievances are transferred to Court.

### 9.9.6 Institutional Framework

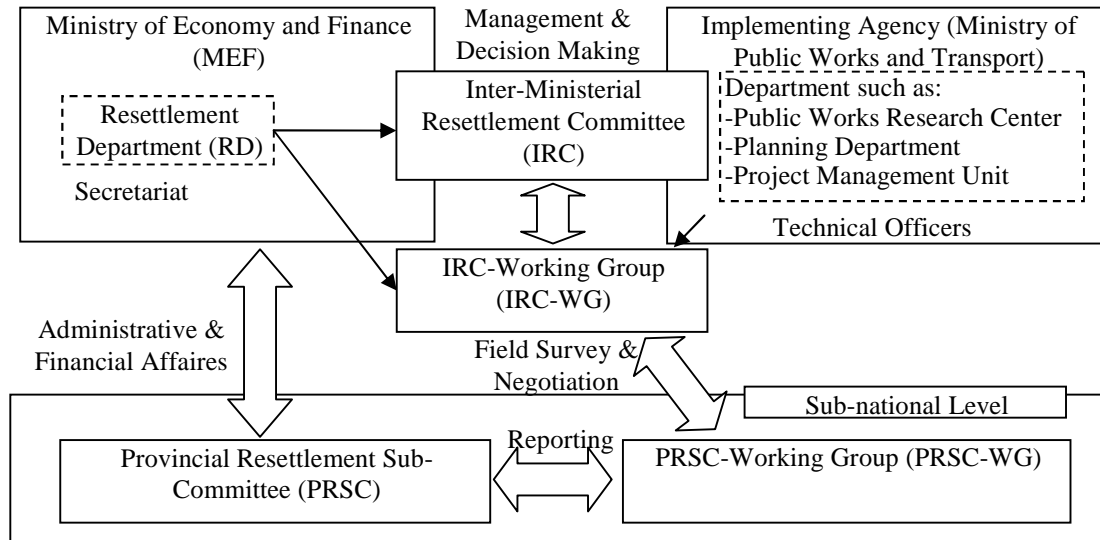
#### (1) Organizations

The MPWT and the Resettlement Department (RD) of MEF are mainly responsible for the land acquisition and resettlement. The organizational structure is shown in Figure 9-7. Another important organization is the Inter-Ministerial Resettlement Committee (IRC) established by request from the MPWT to the MEF for the managing and supervising the land acquisition and resettlement activities. The other committees involved are the IRC-Working Group (IRC-WG) at the national level, Provincial Resettlement Sub-Committee (PRSC) and PRSC-Working Group (PRSC-WG) at the sub-national level as shown in Figure 9-8.



Source: MEF, MPWT, Study Team

**Figure 9-7 Resettlement Department (RD)**



Source: MEF, MPWT, Study Team

**Figure 9-8 Inter-Ministerial Resettlement Committee (IRC) and Relevant Organizations**

**(2) Roles of Related Organizations**

Major roles and responsibilities of the respective organizations by the work step are summarized as follows.

- 1) RD (MEF): Managements of Detailed Measurement Survey (DMS) and Replacement Cost Study (RCS), Budget Disbursement
- 2) MPWT: Designing, Census (Number of Affected Persons, Socio-economic Survey), Public Consultation Meeting (PCM), Resettlement Action Plan (RAP) if necessary, Assignment of Staff and Verification of Results for DRM, Implementation of Internal Monitoring
- 3) IRC: Management and Supervision of DMS, Approval of Budget Disbursement, Management of External Monitoring and Evaluation
- 4) IRC-WG: Implementation of DMS, Negotiation and Contract with PAPs, Compensation Payment
- 5) PRSC: Cooperation with IRC-WG for DMS, Management of Compensation Payment
- 6) PRSC-WG: Implementation of DMS with IRC-WG, Negotiation and Contract with PAPs, Compensation Payment
- 7) Grievance Redress Committee: Receive and Resolution of Grievance
- 8) Court: Final Decision
- 9) Independent Consultants: Implementation of RCS

### **9.9.7 Implementation Schedule**

The Project implementation schedule is still unclear in the Study. The MPWT will plan some packages by grouping several bridges on the respective priority of the road for the Project implementation.

### **9.9.8 Cost and Finance**

As Table 9-3 shows, the cost of land acquisition and resettlement will be calculated with the RCS based on Detailed Measurement Survey (DMS) in design/procurement stage of the Project. The RCS is intended to provide fair and proper compensations for the structures, land and other fixed properties affected by the bridge replacement projects based on market value or other alternative measures. The “Expropriation Law 2010, Article 22” stipulates that the amount of compensation shall be based on the market price or replacement cost, which is equivalent to the international development partners’ safeguard policies of WB and ADB. The RD and the IRC take on the responsibility to allocate and disburse the budget of land acquisition and resettlement.

### **9.9.9 Monitoring System**

The government is responsible for the monitoring to verify the compliance to RAP and identify issues during resettlement implementation. The monitoring also provides possible recommendations so that the implementation arrangements will be adjusted and successfully completed. The monitoring system in Cambodia consists of two types, internal monitoring and external monitoring. The internal monitoring is conducted by project implementation agency (IRC and MPWT), which includes regular monitoring and evaluation of implementation of RAP. The external monitoring and post-evaluation study are conducted by an external monitoring agency which is an independent institution or group hired by IRC. The external monitoring assesses the resettlement implementation activities and its impacts, the internal reporting and monitoring activities.

Monitoring indicators are assumed as:

- 1) Entitlements of PAPs under the approved entitlement policies;
- 2) Assessment of compensation under the agreed procedures;
- 3) Payment of compensation as stated in the RAP;
- 4) Public information, public consultation and grievance procedures as stated in the RAP;
- 5) Payment of compensation in a timely manner; and
- 6) Relocation, if any, in a timely manner.



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**CHAPTER 10**  
***IMPLEMENTATION PROGRAM***

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## 10. IMPLEMENTATION PROGRAM

### 10.1 Target Bridges for the Replacement Plan

Replacement plans for target bridges including temporary bridge, bridge overflow by flood water and one lane bridge are examined in this chapter. The target bridges identified through the survey are classified as follows:

**Table 10-1 Summary of the Target Bridges**

Classification of bridge	Type of bridge		Number of bridge
Temporary bridge	A	Wooden bridge	40
	B	Bailey bridge	54
	C	Temporary steel bridge	16
	D	Temporary concrete bridge	4
	E	Bridge of grade3	2
	Sub total		116
Bridge over flow by a flood	F	Bridge deck overflow by the flood	17
	G	High water level reach to the bridge girder	8
One lane Bridge	H	Concrete one lane bridge	78
Total			219

**Table 10-2 Number of the Target Bridges on Each Road**

Priority No.	Road No.	Temporarily Bridge					Total	Over flow, One Lane Bridge			Total
		A	B	C	D	E		F	G	H	
1	11	0	0	2	0	0	2	0	0	0	0
2	73	0	6	0	0	0	6	0	0	0	0
3	314D	0	1	0	0	0	1	0	0	0	0
4	42	0	0	0	1	0	1	2	0	3	5
5	267	0	0	1	0	0	1	0	0	0	0
6	2624	0	1	0	0	0	1	0	0	0	0
7	70	0	2	0	0	0	2	0	0	0	0
8	279	0	0	1	0	0	1	0	0	8	8
9	151B	0	4	0	0	0	4	0	0	0	0
10	155	3	1	2	0	0	6	0	0	1	1
11	2620	0	1	0	0	0	1	0	0	2	2
12	314C	0	1	0	0	0	1	0	0	0	0
13	377	0	6	6	0	0	12	0	0	0	0
14	264C	2	0	0	0	0	2	0	0	0	0
15	277	0	2	0	0	0	2	0	0	2	2
16	316A	0	1	0	0	0	1	0	0	0	0
17	375	3	0	0	1	0	4	0	0	0	0
18	373B	0	0	0	1	0	1	0	0	0	0
19	372A	0	5	0	0	0	5	0	0	0	0
20	373D	10	0	0	0	0	10	0	0	0	0
21	156	0	2	0	0	0	2	0	0	2	2
22	154	2	0	1	0	0	3	0	0	0	0
23	266C	0	1	0	0	0	1	0	0	0	0
24	136	1	0	0	0	0	1	0	0	1	1
25	154B	1	0	0	0	0	1	0	0	0	0
26	155B	3	0	0	0	0	3	0	0	0	0
27	371D	0	1	0	0	0	1	0	0	0	0
28	380A	0	1	0	0	0	1	0	0	0	0
29	152H	1	0	0	0	0	1	0	0	0	0
30	156D	2	1	0	0	0	3	0	0	1	1
31	155A	0	1	0	0	0	1	0	0	0	0
32	317C	0	0	0	0	1	1	0	0	1	1
33	46	0	3	1	0	0	4	0	0	0	0
34	159B	0	1	0	0	0	1	0	0	0	0
35	2646	0	2	0	0	0	2	0	0	0	0
36	137	0	1	0	0	0	1	0	0	4	4
37	266	0	1	0	0	0	1	0	0	2	2
38	53A	0	1	0	0	0	1	0	0	0	0
39	154C	1	0	0	0	0	1	0	0	1	1
40	154E	2	0	0	0	0	2	0	0	0	0
41	154F	3	0	0	1	0	4	0	0	0	0
42	155E	1	0	0	0	0	1	0	0	0	0
43	265	1	0	0	0	0	1	0	0	0	0



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Priority No.	Road No.	Temporaly Bridge					Total	Over flow, One Lane Bridge			Total
		A	B	C	D	E		F	G	H	
44	383	0	5	0	0	0	5	0	0	0	0
45	374	0	2	0	0	0	2	0	0	0	0
46	53B	0	0	2	0	0	2	0	0	0	0
47	265C	1	0	0	0	0	1	1	0	1	2
48	265E	0	0	0	0	1	1	0	0	0	0
49	62	0	0	0	0	0	0	1	0	0	1
50	68	0	0	0	0	0	0	1	0	0	1
51	152D	2	0	0	0	0	2	0	0	1	1
52	152F	1	0	0	0	0	1	0	0	0	0
53	260	0	0	0	0	0	0	0	1	0	1
54	159D	0	0	0	0	0	0	0	1	0	1
55	313	0	0	0	0	0	0	3	0	0	3
56	67	0	0	0	0	0	0	1	0	0	1
57	261	0	0	0	0	0	0	0	2	0	2
58	147	0	0	0	0	0	0	0	0	4	4
59	156A	0	0	0	0	0	0	2	1	1	4
60	114	0	0	0	0	0	0	0	1	0	1
61	130	0	0	0	0	0	0	0	0	6	6
62	154A	0	0	0	0	0	0	0	1	4	5
63	135	0	0	0	0	0	0	0	0	1	1
64	157C	0	0	0	0	0	0	0	0	1	1
65	129C	0	0	0	0	0	0	0	0	1	1
66	129	0	0	0	0	0	0	0	0	1	1
67	136A	0	0	0	0	0	0	0	0	3	3
68	157B	0	0	0	0	0	0	1	0	1	2
69	134B	0	0	0	0	0	0	0	0	2	2
70	266E	0	0	0	0	0	0	2	0	1	3
71	317B	0	0	0	0	0	0	0	0	1	1
72	153	0	0	0	0	0	0	0	0	1	1
73	268B	0	0	0	0	0	0	0	0	2	2
74	133A	0	0	0	0	0	0	0	0	2	2
75	314	0	0	0	0	0	0	0	0	1	1
76	387A	0	0	0	0	0	0	1	0	0	1
77	153C	0	0	0	0	0	0	0	0	1	1
78	313A	0	0	0	0	0	0	0	0	1	1
79	387	0	0	0	0	0	0	0	0	2	2
80	152G	0	0	0	0	0	0	0	0	1	1
81	121	0	0	0	0	0	0	0	0	1	1
82	153B	0	0	0	0	0	0	0	0	2	2
83	152	0	0	0	0	0	0	0	0	1	1
84	265B	0	0	0	0	0	0	1	0	1	2
85	268A	0	0	0	0	0	0	0	0	5	5
86	156C	0	0	0	0	0	0	1	1	0	2
Total		40	54	16	4	2	116	17	8	78	103

## **10.2 Concept for the Implementation Program**

In order to carry out replacement of the target bridges within the constraints of limited budget, short-term, medium-term and long-term bridge replacement plans shall be established based on the priority of the target roads in principle, however, the other factors such as traffic safety, durability of bridges and influence of the regional development shall be taken into consideration. Bridge is a part of roads and road networks are an essential infrastructure for the regional development; therefore bridges shall not be improved independently. The target bridges allotted to each term shall be determined taking into consideration the following conditions;

- 1) Priority of the target roads
- 2) Priority group of the target roads
- 3) Durability of bridge taking into account the traffic safety
- 4) Imperfection of bridge functions including one lane carriage way on the two lane road as a parts of the road.

### **(1) Short-term Plan**

The bridges in Group 1 and 2 are recommended as first priority for improvement in the short-term plan. Considering the priority of the target roads, the target roads with high priority above 20 will be recommended as the second priority group of the target roads for the short-term plan.

### **(2) Medium-term Plan**

All of the remaining temporary bridges not included in the short-term plan shall be replaced to permanent structures in the medium-term plan.

### **(3) Long-term Plan**

There are lots of concrete bridges including bridges inundated by flood water on the target roads. These concrete bridges were constructed within 20 years by the Cambodia and they have higher durability compared to the temporary bridges. However, the majority of the concrete bridges have only one-lane carriage way and are prone to traffic accidents on the two-lane road. Therefore they shall be replaced in the long-term plan.

Based on the above concepts, the implementation program for each category of roads is examined taking into consideration the available funds. The implementation program and project cost in each term are shown in Table 10-3.

**Table 10-3 Implementation Program of concept and budget**

<b>Term</b>	<b>Classification</b>	<b>Budget of Bridge Construction (Mill USD)</b>	<b>Cost of Bridge Replacement (Mill USD)</b>
Short-term (2013-2017)	First Priority Group of Temporary Bridges Second Priority Group of Temporary Bridges	374	62
Medium-term (2018-2022)	All of the remaining of Temporary Bridges	430	36
Long-term (2023-2027)	Concrete one lane bridges and bridges over flow by flood water	430	60

### **10.3 Allocation Plan**

The target bridges on the road selected according to each term are shown in Table 10-4. The costs are not include administration and supervising fee.

**Table 10-4 Road List for Each Term**

Short term Plan (2013-2017)				Medium term Plan (2018-2022)				Long term Plan (2023-2027)			
Pri. No.	Road No.	Number of Bridge	Cost (USD)	Pri. No.	Road No.	Number of Bridge	Cost (USD)	Pri. No.	Road No.	Number of Bridge	Cost (USD)
1	11	2	4,233,259	21	156	2	2,508,170	4	42	5	2,075,615
2	73	6	14,441,352	22	154	3	1,920,452	8	279	8	13,267,699
3	314D	1	508,472	23	266C	1	1,238,966	10	155	1	270,369
4	42	1	320,747	24	136	1	432,683	11	2620	2	1,118,346
5	267	1	397,524	25	154B	1	421,153	15	277	2	456,582
6	2624	1	2,733,221	26	155B	3	1,682,216	17	375	1	302,138
7	70	2	4,014,307	27	371D	1	727,617	21	156	2	902,923
8	279	1	3,170,040	28	380A	1	512,589	24	136	1	710,051
9	151B	4	2,175,579	29	152H	1	532,083	30	156D	1	331,552
10	155	6	2,429,494	30	156D	3	2,275,653	32	317C	1	277,383
11	2620	1	2,863,869	31	155A	1	842,998	36	137	4	1,264,209
12	314C	1	1,033,501	32	317C	1	284,707	37	266	2	612,389
13	377	12	13,371,630	33	46	4	2,849,674	39	154C	1	282,872
14	264C	2	821,664	34	159B	1	965,935	47	265C	2	1,605,006
15	277	2	1,447,291	35	2646	2	1,147,574	51	152D	1	286,405
16	316A	1	591,837	36	137	1	307,306	49	62	1	1,162,255
17	375	3	1,773,503	37	266	1	664,991	50	68	1	1,531,698
18	373B	1	316,660	38	53A	1	1,517,518	53	260	1	1,394,613
19	372A	5	2,452,042	39	154C	1	300,292	54	159D	1	689,212
20	373D	10	3,301,477	40	154E	2	955,418	55	313	3	2,697,651
				41	154F	4	1,548,199	56	67	1	965,660
				42	155E	1	621,290	57	261	2	1,662,787
				43	265	1	504,954	58	147	4	1,366,151
				44	383	5	5,139,521	59	156A	4	2,722,476
				45	374	2	1,248,338	60	114	1	829,746
				46	53B	2	598,473	61	130	6	3,321,534
				47	265C	1	2,158,379	62	154A	5	1,493,262
				48	265E	1	298,927	63	135	1	277,443
				51	152D	2	1,462,730	64	157C	1	327,164
				52	152F	1	340,081	65	129C	1	329,860
								66	129	1	632,205
								67	136A	3	1,673,221
								68	157B	2	747,750
								69	134B	2	638,105
								70	266E	3	1,517,596
								71	317B	1	274,648
								72	153	1	494,796
								73	268B	2	718,247
								74	133A	2	688,212
								75	314	1	581,047
								76	387A	1	447,439
								77	153C	1	550,038
								78	313A	1	288,961
								79	387	2	769,979
								80	152G	1	302,540
								81	121	1	322,796
								82	153B	2	965,145
								83	152	1	291,596
								84	265B	2	1,019,153
								85	268A	5	1,458,016
								86	156C	2	1,090,373
<b>First Priority Group</b>			<b>50,655,371</b>	<b>Total Cost (USD)</b>			<b>36,008,887</b>	<b>Total Cost (USD)</b>			<b>60,006,914</b>
<b>Second Priority Group</b>			<b>11,742,098</b>	<b>Total Cost (USD)</b>			<b>36,008,887</b>	<b>Total Cost (USD)</b>			<b>60,006,914</b>
<b>Total Cost (USD)</b>			<b>62,397,469</b>	<b>Total Cost (USD)</b>			<b>36,008,887</b>	<b>Total Cost (USD)</b>			<b>60,006,914</b>

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**CHAPTER 11**  
***CONCLUSION AND RECOMMENDATIONS***

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## **11. CONCLUSIONS AND RECOMMENDATIONS**

### **11.1 Conclusions**

#### **(1) General**

In this project, 1205 bridges on 168 roads including 2-, 3- and some 4-digit roads administrated by the MPWT and the MRD have been investigated through this project. Many bridges on the road have been improved with permanent bridges by the Government of Cambodia and with support of donor countries and agencies. On the other hand, 200 bridges which need to be replaced with permanent bridges still remain on the road. Failure of such inferior bridges on the road will cause serious damage to the economy of the society as analyzed in this report.

#### **(2) Temporary Bridges Requiring Replacement**

The temporary bridges including wooden bridges, temporary steel bridges, temporary concrete bridges and bridge with grade three deficiency require the most urgent replacement because of their vulnerability to modern traffic. Bailey bridges have some strength for the traffic because they are designed for the emergency opening of roads in the event of war. However the Bailey bridges are designed for temporary use and they do not have enough durability over long periods. There are lots of one-lane concrete bridges which have been constructed by the Cambodia. The majority of them are constructed within 20 years and have some strength for the existing traffic, however as roads are improved to two traffic lanes, the one-lane bridges hinder modern traffic and cause traffic accidents.

The bridges on the roads which shall be replaced with permanent bridges and the degree of urgency for their replacement are as follows:

- 1) Temporary bridges including Bailey bridge, wooden bridge and others.
- 2) Bridges with insufficient bridge opening, i.e. the bridges that suffer with flood water.
- 3) Bridges with insufficient carriageway width compared to road way width.

### **11.2 Recommendation**

#### **(1) Priority Setting for the Replacement of the Temporary Bridges**

The temporary bridges and bridges with insufficient bridge functions shall be replaced to permanent bridges with sufficient functions. However, there are budget constraints to

carrying out the replacement of all bridges on roads. The bridges shall be replaced in accordance with the priority of bridges which was designated in Chapter 10.

**(2) Establishment of Data base system for Bridge Maintenance**

The bridges nominated in this project are only a part of bridges in Cambodia. There are lots of bridges still remaining unimproved in local areas and they are an important infrastructure for the development of the region. A bridge data system including inventory system and inspection system shall be developed for the reasonable and systematic approach to improve large number of inferior bridges.

**(3) Development of Construction Companies in Cambodia for Bridge Construction**

The construction companies in Cambodia do not have enough capability for bridge construction yet, however there are modern bridges that were constructed by the Cambodian army. The bridges have enough durability for existing traffic load. The bridge construction technology owned by the Cambodian army and foreign contractors shall be transferred to the private construction companies in Cambodia.

**(4) Introduction of Modern Construction Technology**

The majority of bridges constructed by Cambodian people are reinforced concrete bridges. They are constructed by very conventional methods and they have some limitations regarding the scale of bridge including its span length. Some modern construction technologies including pre-stressed concrete shall be introduced through a pilot project as new technologies for Cambodia.

**(5) Implementation of Preventive Bridge Maintenance**

As recommended in the Section 6 Economic Evaluation, inferior bridges shall be replaced under a preventive maintenance plan. Once a bridge is closed to the traffic, the loss for regional economy and traffic on the road is unbearably big. The economic benefit of bridge replacement by the preventive maintenance plan compared to the breakdown maintenance is obvious.



**(6) Establishment of an Emergency Bridge Opening Unit.**

There are still a lot of temporary bridges on roads in Cambodia for the time being. As described in Chapter 6, closure of the road to the traffic causes a severe loss for the regional economy. The cost of traffic loss increases as the closed time grows. The emergency bridge opening unit, which keeps several sets of Bailey bridges for emergency opening in the event of bridge failure, is very effective for opening the traffic within a short time period.

**(7) Recommendations**

Following actions are recommended to maintain all remaining inferior bridges.

- 1) Establish database system for all road infrastructures.
- 2) Establish a bridge management system including bridge inventory and inspection...
- 3) Improve the capacity of bridge maintenance as recommended in Package B of this project.
- 4) Raising private construction company.
- 5) Introduce modern bridge technology including bridge design and construction
- 6) Replace inferior bridges before closing traffic due to the bridge failure.
- 7) Establish an emergency bridge opening unit within the MPWT and MRD.



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**CHAPTER 12**  
***BRIDGE MAINTENANCE (PACKAGE B)***

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## 12. BRIDGE MAINTENANCE (PACKAGE B)

### 12.1 Bridge Maintenance

Improvement of the road network is urgent to support the sharp economic development in Cambodia. Renovation of roads and bridges has been carried out rapidly since 2000. However, there are still many temporary bridges on the road network and they have a harmful influence on the current traffic. Additionally, periodic bridge inspection and maintenance have not been implemented and accidents caused by the poor maintenance activities such as bridge collapse have occurred often. In order to improve the situation, a study for the capacity development of the bridge management is being carried out.

#### 12.1.1 General Condition of Bridges in Cambodia

##### (1) Status of roads and bridges

According to the Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia, total length of roads is 44,709km and total number of bridges is 4,060. Length of roads managed by the MPWT is 11,704km, 2,117km of which are 1-digit roads, 3,146km of which are 2-digit roads and 6,441km of which are 3- and 4-digit roads. The number of bridges on those categories of roads is 589, 698 and 904 respectively. Table 12-1 shows the present condition of roads and bridges in Cambodia.

**Table 12-1 Present Condition of Roads and Bridges in Cambodia**

Road Classification	Road Length		No. of Bridges		Management Authority
	Length (km)	Percentage (%)	Count	Percentage (%)	
1-digit Roads	2,117	4.7%	589	14.5%	MPWT
2-digit Roads	3,146	7.0%	698	17.2%	
3, 4-digit Roads	6,441	14.4%	904	22.3%	
Sub-total	11,704	26.2%	<b>2,191</b>	54.0%	
Rural Roads	33,005	73.8%	1,869	46.0%	MRD
Total	44,709	100%	4,060	100%	

Source: Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia (MPWT and MRD)

Note: MPWT road length and number of bridges are as of 2009 and 2006 respectively. MRD road length and no. of bridges are as of 2010.

On the other hand, 2,228 bridges which consist of 793 permanent bridges and 1,435 temporary bridges are listed in the HEC inventory data as of 2006. About two thirds of the total bridges were temporary bridges. Table 12-2 shows the number of bridges managed by the HEC inventory data.

**Table 12-2 Number of Bridges managed by the MPWT as of 2006 Unit: No/(%)**

Item	Type of Bridge	National Road		Provincial Road		Total
		1-digit	2-digit	3-digit	4-digit	
Permanent	Concrete	290 (68.9)	100 (16.7)	28 (3.9)	122 (25.1)	793 (35.6)
Temporary	Bailey	74 (17.6)	204 (34.1)	185 (25.6)	92 (18.9)	555 (24.9)
	Steel	45 (10.7)	43 (7.2)	42 (5.8)	28 (5.8)	158 (7.1)
	Timber	11 (2.6)	244 (40.7)	214 (29.6)	244 (50.2)	713 (32.0)
	Stone	1 (0.0)	8 (1.3)	0 (0.0)	0 (0.0)	9 (0.4)
	Sub-total	131 (31.1)	499 (83.3)	441 (61.0)	364 (74.9)	1,435 (64.4)
Total		421	599	722	486	<b>2,228</b>

Source: Bridge Inventory provided by the HEC (MPWT), 2006

Table 12-3 shows the number of bridges surveyed by the Study Team. The survey was carried out on 2-, 3- and some 4-digit roads(the target bridges). The bridges surveyed by the Study Team are part of all the bridges managed by the MPWT. The percentage of temporary bridges was 64.4% in 2006 which decreased to 36.0% in 2012.

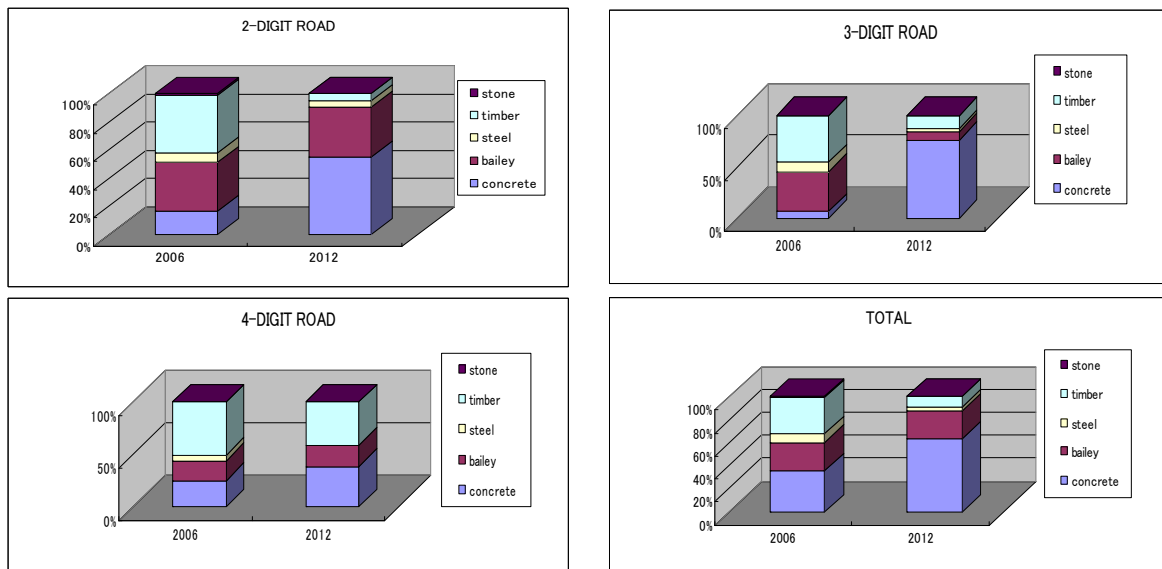
**Table 12-3 Number of Bridges investigated in 2012**

Unit: No/(%)

Item	Type of Bridge	National Road	Provincial Road		Total
		2-digit	3-digit	4-digit	
Permanent	Concrete	370	383	14	767
		55%	76%	44%	64%
Temporary	Bailey	232	47	6	285
		35%	9%	19%	24%
	Steel	31	19	0	50
		5%	4%	0%	4%
	Timber	35	56	12	103
		5%	11%	38%	9%
	Stone	0	0	0	0
Sub-total	298	122	18	438	
	45%	24%	56%	36%	
Total		668	505	32	<b>1205</b>

Source: Study Team

Figure 12-1 shows the transition of bridge type from 2006 to 2012. There is not much change of bridge type for 4-digit roads, but for 2- and 3-digit roads many bridges have been changed to a new bridge type due to replacement of temporary bridges. Many temporary bridges, including wooden bridges and Bailey bridges, have been replaced with concrete bridges. The number of Bailey bridges on 2-digit roads shows little change but among 232 Bailey bridges, 195 bridges are planned to be replaced.



**Figure 12-1 Change of the bridge type**

Construction year of bridges as indicated in the bridge inventory 2012 is shown in Table 12-4. The number of bridges constructed since 2001 is 312 which includes the bridges under construction, and the construction year of other bridges was not identified

**Table 12-4 Construction Year of Bridges in Cambodia**

Type of Bridge	Construction Year					total
	Unknown	Before 1990	1991 -2000	2001 -2005	2006 -2012	
Concrete	440	12	24	73	190	739
Bailey	267	0	1	9	8	285
Steel	44	1	1	2	2	50
Timber	101	0	2	0	0	103
Under construction	-	-	-	-	28	28
Total	852	13	28	84	228	1205

Source: Study Team

**(2) Replacement of the bridges**

Since reconstruction and rehabilitation of road infrastructure started early in the 1990s funded by donor countries and the Cambodia, many temporary bridges along national and provincial roads have been replaced by two lane concrete bridges. However, the remaining bridges other than replaced bridges are damaged and/or have insufficient loading capacity for the current transport demands.

A road network master plan targeting year 2020 has been developed in the “Study on the Road Network Development in the Kingdom of Cambodia, 2006” (hereinafter referred to as the road network development plan) conducted by JICA. Based on the study, the Cambodia has up-graded existing roads and replaced temporary bridges to permanent bridges funded by the Cambodia and donor countries. The recent situations of bridge construction in Cambodia are shown in Table 12-5. The number of bridges listed in the bridge development plan in the “Follow-up Study on the Road Network Development Master Plan, 2009” (hereinafter referred to as the master plan) is 289. The number of bridges planned to be replaced in the short term (2008~2013) is 50, in the medium-term (2014~2018) is 138, and in the long term (2019~) is 101. Disregarding the master plan, 172 of those bridges have already been completed and 138 bridges are now under construction.

**Table 12-5 Recent Situation of Bridge Construction**

Status		No. of Bridges
Waiting for Construction <sup>*1</sup>	Short Term (2008~2013)	50
	Mid Term (2014~2018)	138
	Long Term (2019~)	101
	Sub-total	289
Construction <sup>*2</sup>	On-going	138
	Completed	172
	Sub-total	310
Total		599

Source: <sup>\*1</sup> Follow Up Study on the Road Network Development Master Plan by JICA, March 2009

<sup>\*2</sup> Project Profile & Progress of Land Transport Infrastructure (year 2005 –Present)

**(3) Types of Bridges**

There are two types of bridges in Cambodia in general, one is a temporary bridge and the other is a permanent bridge. A permanent bridge is a bridge that is expected to serve for more than 100 years and satisfy the required functions as a bridge. The concrete bridge and steel bridge with two or more lanes correspond to these criteria. A temporary bridge is a bridge that does not fulfil the functions required as bridge including loading capacity and it is required to be replaced to the a permanent bridge in the near future. There are several types of temporary bridges in Cambodia and they are shown in Table 12-6.



**Table 12-6 Type of temporary bridges**

<b>Lack of Function</b>	<b>Type of Bridge</b>
Poor Loading Capacity Bridges can not bear the existing vehicle loading.	Wooden Bridge Stone Bridge Some of Steel Bridge
Lack of Durability The bridge which was originally constructed as a temporary bridge and it is lack of durability.	Bailey Bridge
Lack of Width (one lane) Bridge width of one lane bridge is narrower than the road way width. It is functionally obsolete.	One lane Bridge

Examples of temporary bridges are shown in Photo 12-1 to Photo 12-5.



**Photo 12-1 Timber bridge**



**Photo 12-2 Bailey Bridge**



**Photo 12-3 Steel bridge**



**Photo 12-4 Concrete bridge(1 lane)**



**Photo 12-5 Stone bridge**



The majority of permanent bridges constructed by the Cambodia are reinforced concrete deck girder (RCDG) and many pre-stressed concrete (PC) girders are constructed by the donor countries. Ages of these bridges are less than 15 years and many of those bridges do not require large-scale repair other than the routine maintenance. There are some long-span bridges which need special care for maintenance. A list of long-span bridges with a bridge length of 200m or more and maximum span length greater than 50m are shown in Table 12-7.

There are three types of long-span bridges in Cambodia. They are the PC cable-stayed bridge, PC box-girder bridge, and steel box- girder bridge.

**Table 12-7 LIST of long span bridges**

<b>Bridge name</b>	<b>Road No.</b>	<b>River Crossed</b>	<b>Construction year</b>	<b>Type of bridge</b>	<b>Bridge length (m)</b>
Neak loeang Bridge	1	Mekong	Under Construction	PC cable-stayed bridge	2,215
Monivong Bridge	1	Bassac	-	PC box- girder bridge	270
Bassac Bridge	1	Bassac	2009	PC box- girder bridge	855
Chroy changvar Bridge	6A	Tonle sup	1994	steel box-girder bridge	710
Prek taneak bridge	8	Mekong	2010	PC box- girder bridge	1,066
Kizuna bridge	7	Mekong	2002	PC box- girder bridge	1,360
Sekong river supper major bridge	77	Mekong	2007	PC box- girder bridge	1,006
Prec pnov Bridge	Ring road	Tonle sup	2010	PC box- girder bridge	996
Prec Kodam bridge	61	Tonle sup	2010	PC box- girder bridge	981
New campot bay bridge	3	Campot bay	2007	steel box-girder bridge	240

Source: Study Team

Examples of permanent bridges are shown in Photo 12-6 to Photo 12-9.



**Photo 12-6 Monivong Bridge**



**Photo 12-7 Chroy Changvar Bridge**



**Photo 12-8 Kizuna bridge**



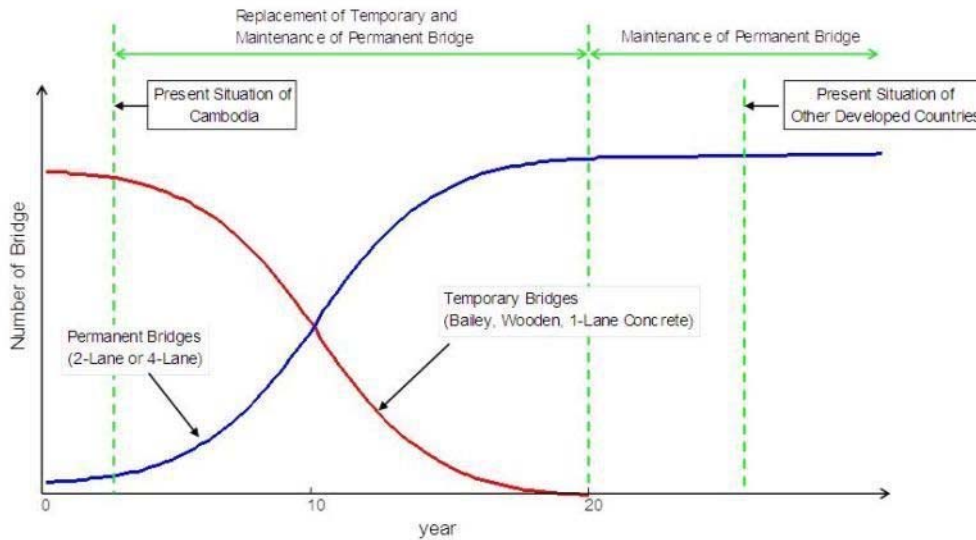
**Photo 12-9 Kompong seung bridge**

## **12.1.2 Bridge Maintenance in Cambodia**

### **12.1.2.1 Bridge Management System (BMS)**

Many temporary bridges still remain in Cambodia and they need to be replaced with permanent bridges. However, certain years are required to replace the temporary bridge to permanent bridges completely because of limited budget. There are some needs to maintain the temporary bridges until they are replaced with the permanent bridge and to prioritize the replacement of temporary bridges.

Status of the bridges replacement in Cambodia is shown in Figure 12-2.



Source: Study Team

**Figure 12-2 Correlation between Replacement and Maintenance of Bridges**

The management of temporary bridges and permanent bridges shall be taken into consideration to establish a BMS in Cambodia.

**(1) Management of temporary bridges**

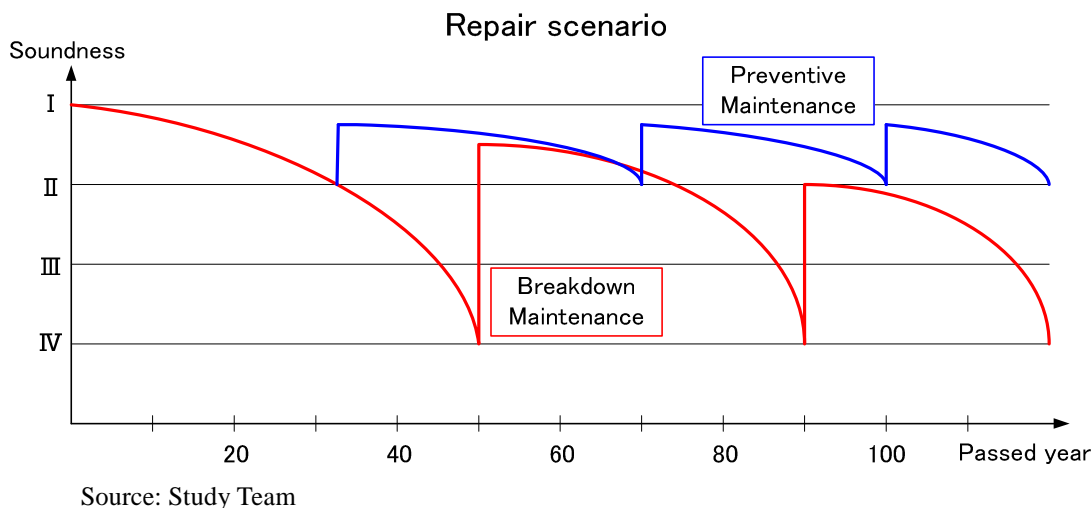
It is necessary to determine the priority of reconstruction of bridges depending on the priority of the road conditions and the deficiency of the bridge. Temporary bridges shall be replaced according to the priority of the roads. It is also necessary to maintain the bridges to secure safe passage on the bridge until the bridge is replaced.

**(2) Management of permanent bridges**

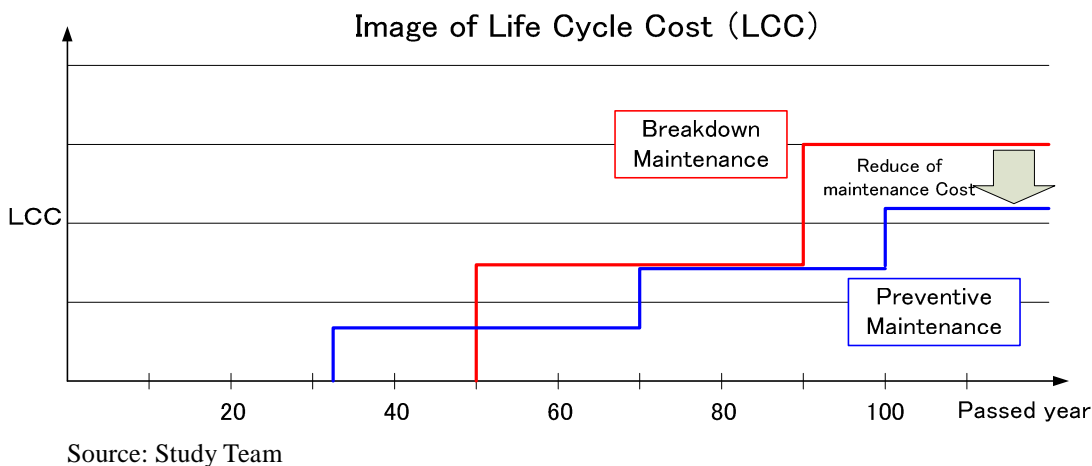
The number of permanent bridges is increasing through the bridge replacement. A large budget has been disbursed to replace temporary bridges with permanent bridges, and the budget for bridge maintenance tends to be constrained.

Bridges are an important asset of the nation and the most expensive facilities on the roads. Car owners always maintain their cars as long as possible considering the life cycle cost until the maintenance cost surpasses the cost of a new car. The same as above, bridges shall be maintained as long as possible considering the life cycle cost of the bridge. The budget for the social infrastructure could be reduced by the adoption of the concept of life cycle cost. To determine the life cycle cost, it is necessary to perform bridge inspections periodically in order to determine the degree of bridge deficiency to implement bridge repairs in a reasonable time with the best methods and at a reasonable cost.

Figure 12-3 and Figure 12-4 show the image of the life cycle cost for the reduction of total cost of a bridge by using maintenance activities. Figure 12-4 shows the comparison of the life cycle cost between the cost of a bridge with frequent maintenance and one with long interval maintenance. The relationship between interval of repair and repair cost shall be studied because the repair cost will be lower in the case of the short time interval of repair than the long-time interval.



**Figure 12-3 Repair Scenarios**



**Figure 12-4 Image of Life Cycle Cost**

## **12.2 Existing Condition of Bridge Maintenance in Cambodia**

### **12.2.1 Organization related to Bridge Maintenance in Cambodia**

This chapter describes the organization related to the activities of maintenance of bridges on all roads in Cambodia.

#### **12.2.1.1 Government Sector**

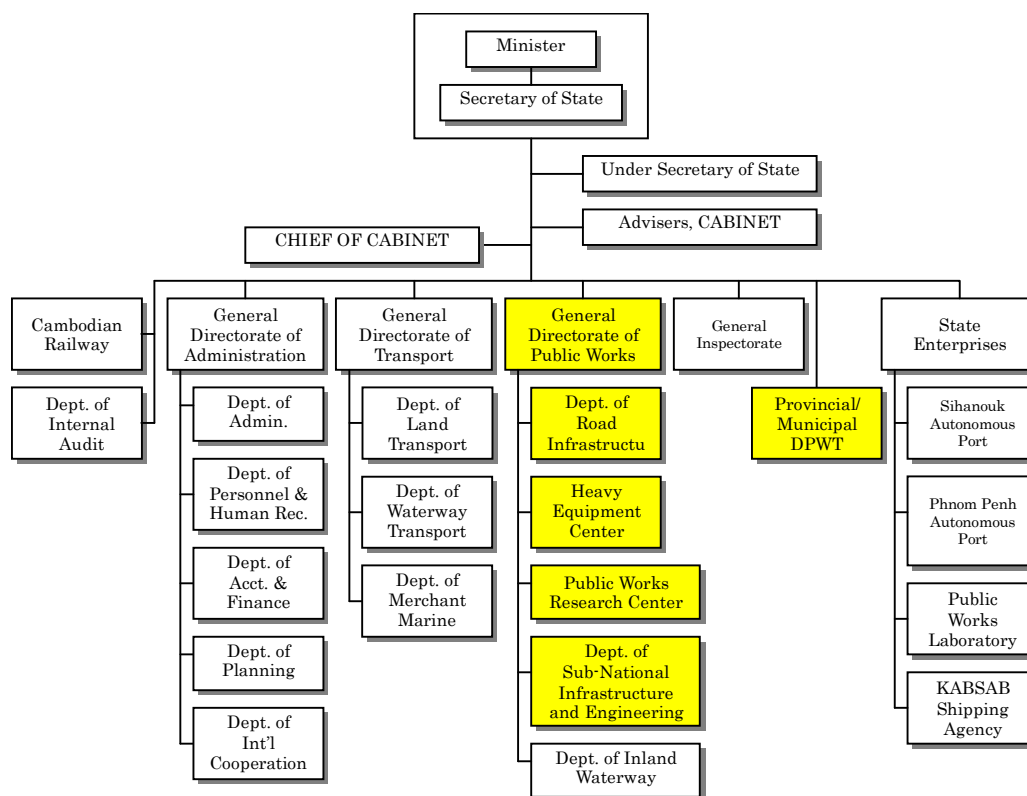
##### **(1) Ministry of Public Works and Transport (MPWT)**

The Ministry of Public Works and Transport (MPWT) is responsible for management and maintenance of national roads in 1- and 2-digit, provincial roads in 3-digit and some roads in 4-digit. However, provincial roads in 3-digit and roads in 4-digit are also managed by the Ministry of Rural Development (MRD). Jurisdiction on management of those roads between the MPWT and the MRD is not clear because of flaws in the present system.

Figure 12-5 shows the present organization of the MPWT. The MPWT consists of three (3) General Directorates, one (1) General Inspectorate, twenty four (24) Provincial/Municipality Public Works and Transport Departments (DPWT), Cambodian Railway, Department of Internal Audit and several State Enterprises. Of these, the General Directorate of Public Works and each the DPWT are closely related to construction and maintenance of roads, bridges and road-related structures, and waterways/canals. The General Directorate of Transport is responsible for management of land, inland waterway and sea transportation.

Mission and Functions of the MPWT are as follows.

- 1) Manage the implementation of national policy concerning the entire public works construction sector through preparation of principles and laws and collaboration with various institutions to develop the country;
- 2) Build, maintain and manage all transportation infrastructures such as roads, bridges, ports, railways, waterways and buildings;
- 3) Establish the regulations for the development of road, port, railway and waterway infrastructures;
- 4) Introduce the regulations and control all road, railway and waterway transportation;
- 5) Participate and cooperate to establish laws, regulations, and standards concerning the construction of transport infrastructure;
- 6) Renovate buildings entrusted by the government; and
- 7) Cooperate with the State Secretariat of Civil Aviation on aeronautical construction.



**Figure 12-5 Organization Chart of the MPWT**

The General Directorate of Public Works consists of three (3) Departments and two (2) Centers – Department of Road Infrastructure (RID), Heavy Equipment Center (HEC), Public Works Research Center (PWRC), Department of Sub-National Public Infrastructure and Engineering (SPIED), and Department of Inland Waterway. Except for the Department of Inland Waterway, the other four (4) departments/centers are involved in construction and maintenance of roads and bridges.

The RID is one of the main actors for road and bridge management in the MPWT in Cambodia. Elaboration of the maintenance program and management of roads and bridges and management of construction sites of roads and bridges are the main duties of the RID.

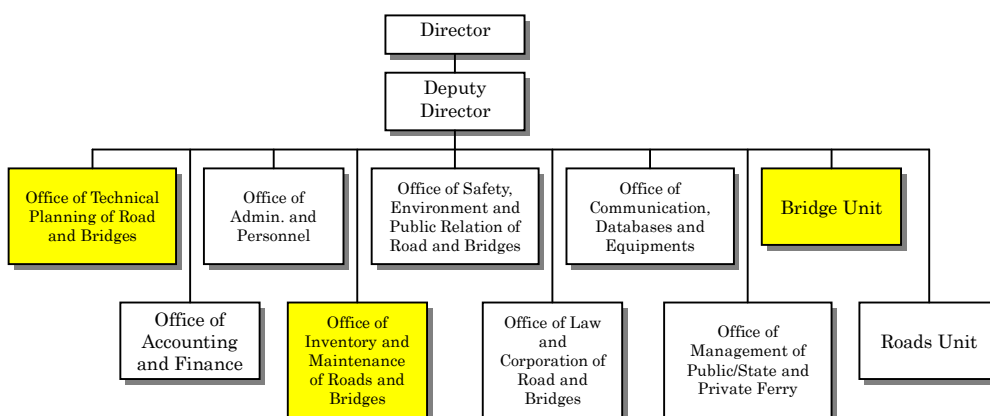
Table 12-8 shows the duties and responsibilities of the RID.

**Table 12-8 Duties and Responsibilities of the Department of Road Infrastructure (RID)**

Elaboration of the maintenance program and management of roads and bridges	<ul style="list-style-type: none"> <li>• Collect data and use essential data to understand the road network;</li> <li>• Manage the technical documents on road use and other construction types, as well as all the information concerning the road network;</li> <li>• Prepare budget and a means to follow up and monitor all maintenance works; and</li> <li>• Manage public properties, roads, waterways and railways.</li> </ul>
Management of construction sites of roads and bridges	<ul style="list-style-type: none"> <li>• Study, manage and produce maintenance programs for roads and bridges;</li> <li>• Prepare budget and a means to follow up and monitor construction of roads and bridges;</li> <li>• Evaluate completed construction sites; and</li> <li>• Manage ferry terminals, barges.</li> </ul>

Source: Decree on Performance and Organization of the Road Infrastructure Department, MPWT

Figure 12-6 shows the organization of the RID. There are eight (8) Offices and two (2) Units in the RID. Of these, four (4) Offices and one Unit – Office of Technical Planning of Road and Bridges, Office of Administration and Personnel, Office of Inventory and Maintenance of Roads and Bridges, Office of Safety, Environment and Public Relation of Roads and Bridges and Bridge Unit - are directly related to maintenance of bridges.



**Figure 12-6 Organization Chart of Road Infrastructure Department (RID)**

The Office of Technical Planning of Road and Bridges proposes technical projects and methods for maintenance and repair of roads and major structures including bridges to the Director of the RID. The Office also collects reports, information and data on maintenance, repair and construction of roads and major structures urgently needed and submits them to the Director of the RID. Moreover, the Office studies and searches for damage to roads and major structures and proposes methods for maintenance and repair of roads and major structures.

The Office of Administration and Personnel proposes training programs for human resources in the RID.

The Office of Inventory and Maintenance of Roads and Bridges prepares and manages data regarding all road facilities of the department and changes and adds new figures annually and regularly.

The Office of Safety, Environment and Public Relation of Roads and Bridges prepares policy and action plans for education on road safety and educates drivers and disseminates information regarding traffic laws related to road safety and environment to the public.

The Bridge Unit examines the condition of bridges and other structures and repairs and maintains those structures.

Table 12-9 shows the duties and responsibilities of those four offices and one unit.



**Table 12-9 Duties and Responsibilities of Offices in the RID**

Office	Duty and Responsibility	
Technical Planning of Road and Bridges	Planning Work	<ul style="list-style-type: none"> <li>• Prepare a development program for a master plan for national, provincial, and provincial-municipal road networks and overpasses;</li> <li>• Produce statistics on roads and bridges of provinces-municipalities, propose technical projects and methods for maintenance and repair, and then submit these documents to the Department of Planning; and</li> <li>• Urgently collect reports/information/data on maintenance and repair, and construction of roads and major structures, and submit to higher level as necessary.</li> <li>• Others</li> </ul>
	Technical Work	<ul style="list-style-type: none"> <li>• Prepare and manage the data system of the department and develop implementation programs for all sectors;</li> <li>• Prepare technical standards for monitoring and evaluation system on road maintenance;</li> <li>• Search for damage to roads and major structures and propose methods for maintenance and repair;</li> <li>• Others</li> </ul>
Administration and Personnel	Human Resources Work	<ul style="list-style-type: none"> <li>• Propose training programs for human resources both inside and outside the country;</li> <li>• Others</li> </ul>
Inventory and Maintenance of Roads and Bridges	<ul style="list-style-type: none"> <li>• Conduct a development research and prepare all documents related to inventory and maintenance of roads;</li> <li>• Monitor the reports and operational work of road maintenance;</li> <li>• Annually and regularly prepare and manage the data regarding all road facilities of the department to change and add new figures as needed for the preparation of plans related to social development;</li> <li>• Others</li> </ul>	
Safety, Environment and Public Relations regarding Roads and Bridges	<ul style="list-style-type: none"> <li>• Prepare policy and action plans for education about road safety;</li> <li>• Collect and disseminate information on traffic accidents;</li> <li>• Educate the public and disseminate information on traffic laws related to road safety and environment to the public;</li> <li>• Others</li> </ul>	
Bridge Unit	<ul style="list-style-type: none"> <li>• Urgent Repair and installation of bridges;</li> <li>• Repair and maintain bridges, sewerage, etc. such as wooden and steel bridge, metal bridge with wooden decks, concrete bridges, small and medium-size bridges, and sewerage construction along the national roads;</li> <li>• Examine the conditions of bridges, compile documents, submitted to the office of technical planning of roads and bridges;</li> <li>• Others</li> </ul>	

Source: Decree on Performance and Organization of the Road Infrastructure Department, MPWT

The HEC and the PWRC are also responsible for bridge management.

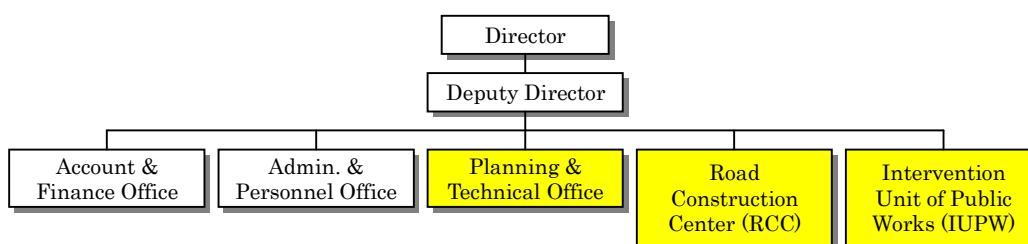
The HEC consists of three (3) offices and one center and one unit. Of these, the Road Construction Center (RCC) is responsible for construction and repair of roads and bridges. RCC started construction of bridges in 2001. A total of 35 bridges including 5 long bridges (90 ~ 100m long) were constructed by RCC. The government of Japan had supported this agency from the beginning by providing facilities and equipment. Therefore, facilities and equipment belonging to RCC are rather new and in good condition compared to facilities and equipment belonging to other departments.

Table 12-10 shows the duties and responsibilities of the HEC and the RCC and Figure 12-7 shows the organization of the HEC.

**Table 12-10 Duties and Responsibilities of the HEC and the RCC**

Department/ Office	Duties and Responsibilities
HEC	<ul style="list-style-type: none"> <li>• Study, research, elaborate and conduct the projects and new construction works on roads and bridges;</li> <li>• Manage and control equipment and mechanical vehicles belonging to Heavy Equipment Center; and</li> <li>• Research and organize training for experts of mechanical vehicles.</li> </ul>
RCC	<ul style="list-style-type: none"> <li>• Construct and repair roads and bridges</li> <li>• Send staff to attend training courses on driving and maintenance of vehicles and equipment</li> <li>• Manage vehicles, equipment and other materials</li> <li>• Others</li> </ul>

Source: PRAKAS on the Organization and Function of Heavy Equipment Center, 05 October 2007



**Figure 12-7 Organization Chart of HEC**

PWRC is responsible for development of technical standards, research and evaluation of projects implemented by the MPWT and quality of construction works and materials and others.

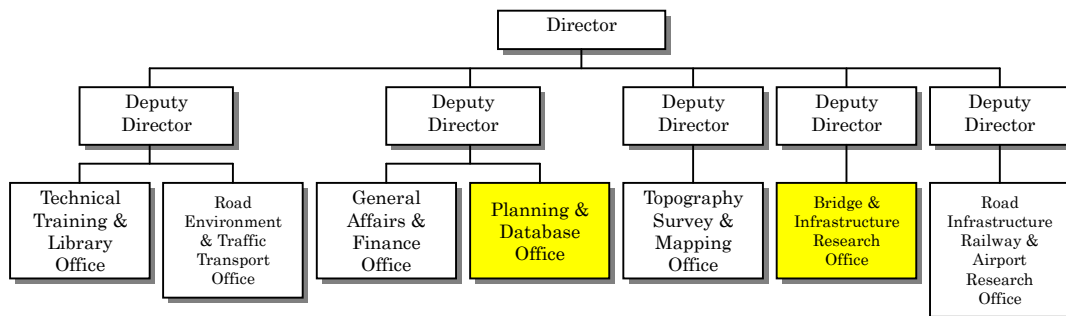
PWRC consists of seven (7) offices. Of these, Technical Training & Library Office, Planning & Database Office and Bridge and Infrastructure Research Office carry out tasks related to bridge management.

The technical assistance project titled “the Strengthening of Construction Quality Control Project” (hereinafter referred to as the quality control project) was implemented by JICA. The PWRC is a counterpart of the project. Table 12-11 shows the duties and responsibilities of the PWRC and Offices in the PWRC.

**Table 12-11 Duties and Responsibilities of PWRC and Offices in PWRC**

Department/ Office	Duties and Responsibilities
PWRC	<ul style="list-style-type: none"> <li>• Develop technical standards and prepare for implementation;</li> <li>• Research and evaluate projects of the MPWT; and</li> <li>• Research and evaluate quality of construction work and construction materials and modern technology for implementation of works of the MPWT.</li> </ul>
Technical Training & Library	<ul style="list-style-type: none"> <li>• Provide training on skills useful for PWRC</li> <li>• Compile documents in library</li> <li>• Others</li> </ul>
Planning & Database	<ul style="list-style-type: none"> <li>• Collect information and data related to infrastructure</li> <li>• Develop digital data system of the PWRC</li> <li>• Others</li> </ul>
Bridge and Infrastructure Research	<ul style="list-style-type: none"> <li>• Research and establish general and basic standards for construction of bridges, ports, ferry terminals and infrastructures</li> <li>• Study detailed designs of bridges, ports, ferry terminals and infrastructures</li> <li>• Others</li> </ul>

Source: PRAKAS on the Organization and Function of the Technical Research Center, 10 February 2000



**Figure 12-8 Organization Chart of Public Works Research Center (PWRC)**

**(2) Department of Public Works and Transport (DPWT)**

Across the Cambodia, there are 24 Provincial Municipal Departments of Public Works and Transport (DPWT). The DPWT is in charge of implementation of activities of the MPWT. The DPWT undertakes the following.

- 1) Inspection, construction and maintenance of national and provincial roads, bridges and other infrastructures on those roads within the jurisdiction of the DPWT by the public works office in the district,
- 2) Registration of vehicles in the province by the transport office, and
- 3) Administration and accounting for the DPWT budget and receiving the national government financial allocation by the administration and financial & planning offices

As mentioned above, the DPWT is in charge of implementation of activities including those of the MPWT. However, the number of staff in the DPWTs has been decreased by the policy of the Government. Not only in the DPWTs but also in other ministries, the number of government employees decreased. Total number of staff in 24 DPWTs was 2,531 and 1,819 in year 2006 and 2011 respectively. The top five (5) DPWT's staff numbers in 2011 were Phnom Penh (310), Prey Veng (168), Kandal (145), Battambang (110), and Kampot (104) respectively. The top 5 in the number of bridges in 2011 were Kandal (287), Pursat (254), Siemreap (174), Kampot (162), and Preah Vihear (119) respectively.

**Table 12-12 Number of Staffs in DPWTs and Bridges in Provinces**

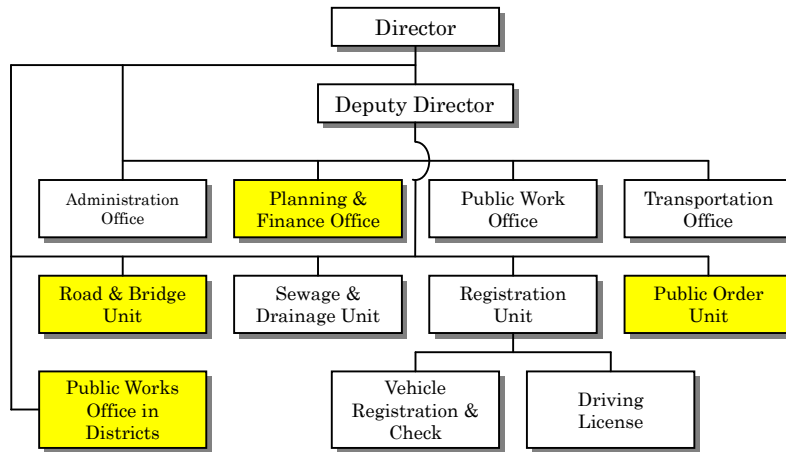
Location of DPWT		No. of Staffs*1		No. of Bridges managed by MPWT by Digit (Year 2006)*2					Year 2011*3
		Year 2006	Year 2011	1-Digit	2-Digit	3-Digit	4-Digit	Total	
1	Banteay Meanchey	88	62	37	9	31	9	86	69
2	Battambang	169	110	22	10	47	27	106	71
3	Kampong Cham	136	104	28	21	74	16	139	108
4	Kampong Chhnang	93	53	23	8	13	3	47	58
5	Kampong Speu	114	70	15	35	22	11	83	106
6	Kompong Thom	96	70	31	5	37	63	136	54
7	Kampot	173	104	19	8	44	6	77	162
8	Kandal	226	145	44	64	136	16	260	287
9	Koh Kong	30	27	8	29	0	2	39	50
10	Kraite	48	37	43	25	25	0	93	88
11	Mondul Kiri	36	28	0	31	0	10	41	29
12	Phnom Penh	408	310	11	0	1	0	12	27
13	Preah Vihear	37	29	0	110	0	134	244	119
14	Prey Veng	265	168	18	22	22	33	95	82
15	Pursat	124	78	35	3	190	10	238	254
16	Ratanak Kiri	32	34	0	56	0	41	97	43
17	Siemreap	76	60	42	59	45	28	174	174
18	Sihanoukville	72	61	22	0	0	0	22	38
19	Stung Treng	40	31	3	8	4	4	19	23
20	Svay Rieng	108	95	5	8	19	19	51	36
21	Takeo	95	70	15	2	12	4	33	31
22	Oddar Meanchey	31	28	0	77	0	48	125	87
23	Kep	10	21	0	0	0	1	1	13
24	Pailin	24	24	0	9	0	0	9	20
Total		2,531	1,819	421	599	722	485	2,227	2,029

Source: \*1-Planning and Administration General Department of MPWT

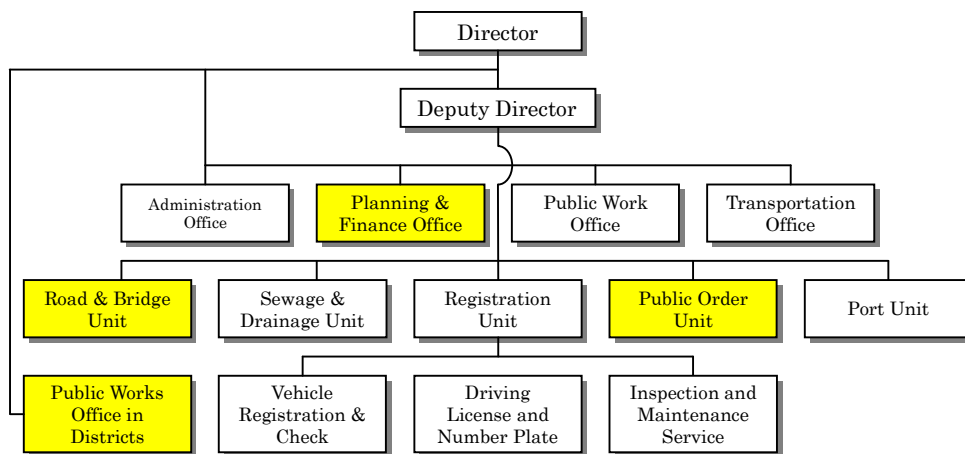
\*2-Bridge Inventory 2006

\*3-Road Maintenance and Construction Year 2011, RID, MPWT

Figure 12-9 and Figure 12-10 show the organization chart of Kandal and Kampong Cham DPWT. Planning & Finance Office, Road & Bridge Unit and Public Order Unit are responsible for road and bridge maintenance.



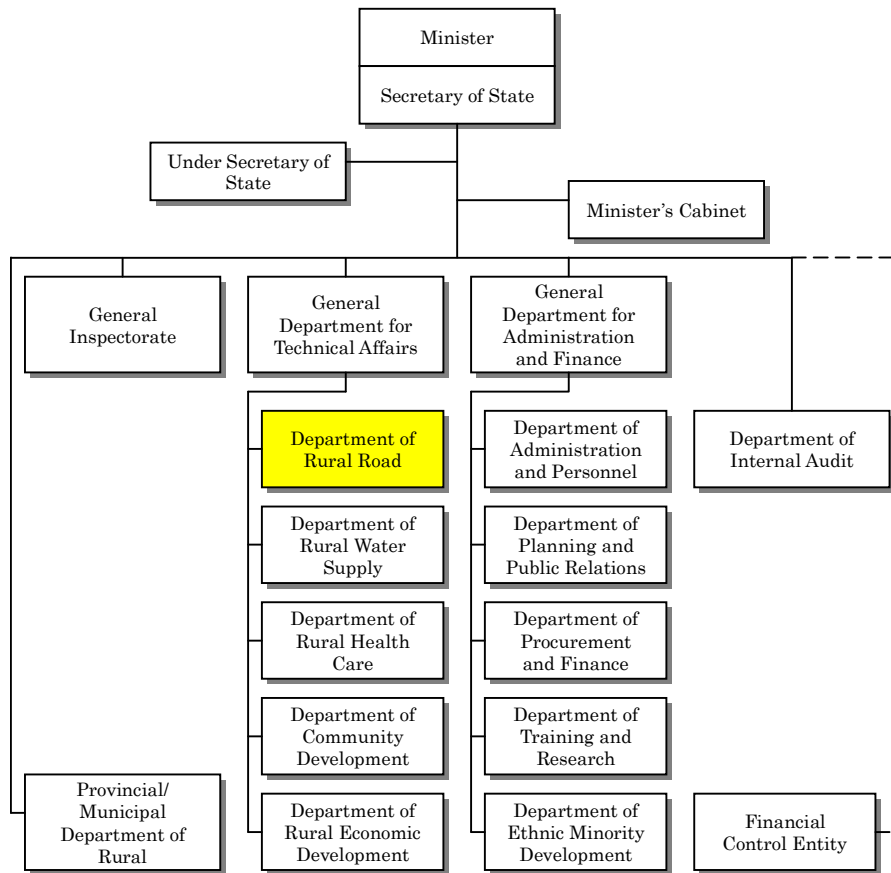
**Figure 12-9 Organization Chart of the DPWT (Kandal Provincial)**



**Figure 12-10 Organization Chart of the DPWT (Kampong Cham Province)**

**(3) Ministry of Rural Development (MRD)**

Figure 12-11 shows the organization chart of MRD.



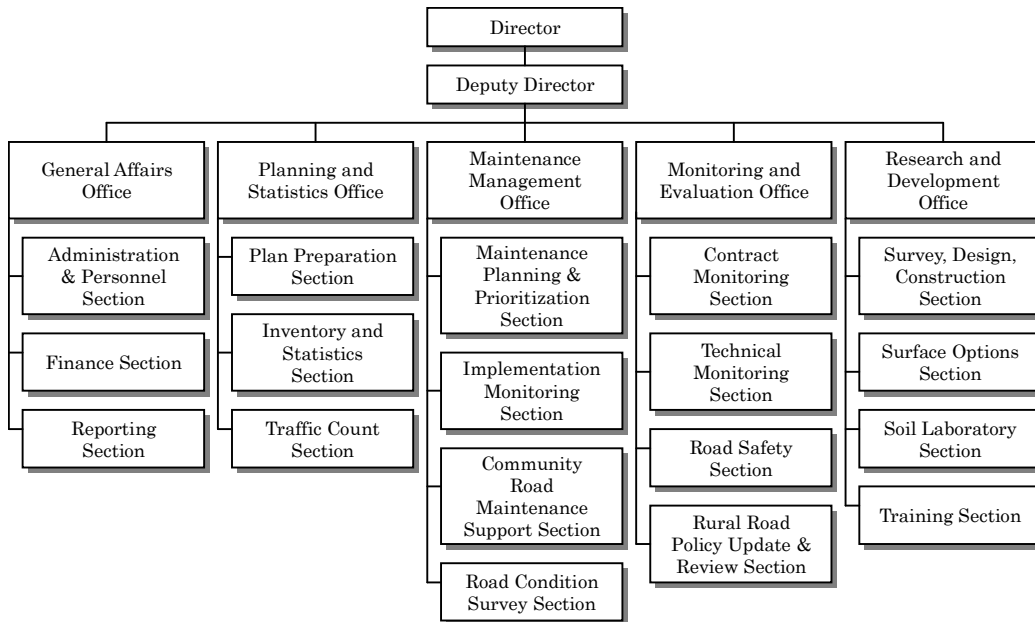
**Figure 12-11 Organization Chart of MRD**

The Ministry of Rural Development (MRD) was established in its current form in 1994. The MRD is one of the road authorities and is responsible for managing and maintaining the bridge on provincial roads.

The Rural Road Policy has been implemented since 1999. The objective of this policy is that the MRD is responsible for facilitating the improvement of the rural social and economic conditions. The Department of Rural Road (DRR) is expected to contribute to this goal by increasing rural access through cost-effective investment in the maintenance and development of rural roads, routes and transport infrastructure.

DRR was formed in 2001 under the Directorate of Technical Affairs. The DRR is assigned to carry out its duties for the management of the rural roads and bridges on rural roads in compliance with the Rural Road Policy.

Figure 12-12 shows the organization chart of MRD. The DRR consists of five (5) offices. Of these, Planning and Statistics Office, Maintenance Management Office, and Research and Development Office are directly responsible for construction and maintenance.



**Figure 12-12 Organization Chart of Department of Rural Road (DRR) in MRD**

DRR has the same responsibility as the DPWT. However, the activity is limited to only rural roads in the provinces. Based on the Policy for Rural Roads the agency prepares annual road improvement and maintenance plans. However, the demarcation of responsibility for roads between the MPWT and the MRD is not clear. The MRD sometimes maintains 2-digit roads or provincial roads based on its own work specifications and standards which differ from those of the MPWT.

Duties of each office are shown in Table 12-13.

**Table 12-13 Duties of Offices in DRR**

Office	Duties
Planning and Statistics Office	<ul style="list-style-type: none"> <li>• To implement and assist the Provincial Department of Rural Development (PDRD) to carry out;</li> <li>• traffic counting and analysis</li> <li>• inventory of all rural roads</li> <li>• To manage the rural road data, statistics and short, medium and long term development plans;</li> </ul>
Maintenance Management Office	<ul style="list-style-type: none"> <li>• To identify, study, research and prioritize the rural roads that need to be maintained throughout the country,</li> <li>• To follow up and ensure the rural road maintenance works are implemented according to the implementation plan;</li> </ul>
Research and Development Office	<ul style="list-style-type: none"> <li>• To carry out and assist the PDRD (PRRO) in the implementation of the surveying, design and construction of rural roads and road structures;</li> <li>• To undertake soil tests for rural roads and the foundations for road structures;</li> <li>• To undertake research and experiments on the selection of pavement materials;</li> </ul>

Source: MRD

**(4) Ministry of Economy and Finance (MEF)**

The MEF is delegated by the government to perform the mission of guidance and administration of the economy and finance of Cambodia in order to support economic development to improve the living standard of Cambodian people based on the principles of a free market economy and social equality.

The MEF has 18 line departments, 1 General Inspectorate and 1 institute. The roles and functions of those line departments have been modified and rationalized to strengthen the Public Financial Reform Program.

The Department of Investment and Cooperation is in charge of the management of public investment and setting priorities for annual investments in order to budget in cooperation with the relevant ministries.

The capital expenditures are negotiated between the MEF and the MPWT. The MPWT requests budgets for road and bridge maintenance every year based on the planned annual maintenance programs. The MEF allocates budgets to the MPWT at the beginning of the year after negotiations are completed. However, the final decision on the annual maintenance budgets is usually delayed.

**(5) Inter-Ministerial Coordination Committee (IMC)**

The Inter-Ministerial Coordination Committee (IMC) for road maintenance and repairs was established on the 8<sup>th</sup> of September, 2006 for evaluation of maintenance program and smooth maintenance activities. Members consist of the MEF and the MPWT.

The roles of the IMC in the budgeting process and project implementation stage are to discuss and come to a consensus on the annual maintenance program which is submitted by the MPWT and to execute random inspections for approval of the contracts by the procurement committee.

**12.2.1.2 Private Sector**

**(1) Consulting Firms and Construction Companies**

There are some private consulting firms and companies related to design and construction of roads and bridges in Cambodia. However, all of the bridge maintenance work (inspection, repair planning and estimation, and repair work) have been implemented by the MPWT and DPWTs themselves in Cambodia. Therefore, private firms and companies have almost no experience in bridge maintenance and no staffs/engineers have been engaged in bridge maintenance works.



**(2) AZ Company**

A toll collecting system started in January 2005, based on the Concession Agreement between RCC in the MPWT and AZ Distribution Co., Ltd. In accordance with the Agreement, AZ has carried out road maintenance on NR4 and has been entitled to collect a charges from road users. AZ developed the maintenance guideline by reference to guidelines of several developed countries.

**12.2.1.3 Higher Education related to the Bridge in Cambodia**

There are five (5) public and eight (8) private universities which have the civil engineering class in Cambodia as of 2012. The Institute of Technology of Cambodia (ITC), which is the oldest and the most prestigious engineering university, was founded in 1964. ITC had been managed based on the government policy of “the Few and the Proud” from the beginning till early 2000. At that time, the number of students in one class in each grade was only 5 to 10. The Government changed the policy of “the Few and the Proud” to “Human Resource Development and Supply” in early 2000. The number of students in one class in each grade has been increased and is around 100 at present. Other universities were founded after year 2000. The number of students in those universities in one class in each grade is now more than 100.

However, engineering universities face difficulty in acquisition of students. High school students tend to avoid engineering universities because of bad images that jobs of engineering are dangerous, dirty, difficult and not intellectually challenging. Almost all of the students that learned civil engineering in the universities gain employment with a private company, not the government sector such as the MPWT because of very low salaries compared to the private sector. Table 12-14 shows universities having civil engineering classes in Cambodia in 2012.

**Table 12-14 Universities having Civil Engineering Classes in Cambodia in 2012**

	Name	Status	Location	Start	Remarks
1	Institute of Technology of Cambodia	Public (MEYS)	Phnom Penh	1964	Bachelor
2	National Polytechnic Institute of Cambodia	Public (MLVT)	Phnom Penh	2005	Bachelor
3	National Technical Training Institute	Public (MLVT)	Phnom Penh	1999	Bachelor and Master
4	University of Battambang	Public (MEYS)	Battambang	2007	Bachelor
5	Mean Chey University	Public (MEYS)	Banteay Meanchey	2007	Bachelor
6	Norton University	Private	Phnom Penh	1996	Bachelor and Master
7	International University	Private	Phnom Penh	2002	Bachelor and Master
8	Cambodia Mekong University	Private	Phnom Penh	2003	Bachelor and Master
9	Build Bright University	Private	Phnom Penh, others	2002	Bachelor
10	Pannasastra University of Cambodia	Private	Phnom Penh	2000	Bachelor
11	Chamroeun University of Polytechnology	Private	Phnom Penh	NI	Bachelor
12	Life University	Private	Sihanoukville	NI	Bachelor
13	Sineru Institute	Private	Phnom Penh	2011	Bachelor

Source: Interviews with each university by the Study Team

#### **12.2.1.4 Board of Engineers Cambodia (BEC)**

The Board of Engineers Cambodia (BEC) has been derived recently from The Engineering Institution of Cambodia (EIC). The BEC is now the sole National Engineering Institution in Cambodia. Its vision is to provide a professional association of registered engineers and to develop their professional qualifications to an internationally accepted standard and, therefore, enhance their contribution to national development and alleviation of poverty. The mission of the BEC is as follows:

- 1) Improvement of the engineering profession for the honour and dignity of engineers;
- 2) Preservation and glorification of national identity;
- 3) Strengthening of technical capacity of all engineering fields and the expansion of the engineering human resources;
- 4) Maintenance of high quality, efficiency, safety, stability, and responsibility in the engineering profession;
- 5) Strengthening and expansion of cooperation and relationships among engineers at national and international levels; and
- 6) Setup of an acceptable standard to recognize and grant the title of Professional

Registration of Engineers in the BEC may be granted upon the award of a degree, and newly academically qualified engineers may progress to professional status after 5 years of

relevant experience. By review of the BEC, existing and experienced engineers may be granted national professional status, and then by further review, to meet the requirements of the ASEAN professional association, they may be granted international status. Registration is open to individuals only. The annual registration fee is \$20.

**Table 12-15 No. of Engineers registered at BEC (as of 2011)**

Item	All Sectors	Civil, Road and Bridge Sector
Registered Engineers	380	43
Professional Engineers	308	42
ASEAN Engineers	217	103

Source: BEC Web Site

## 12.2.2 Institution related to Bridge Maintenance

### 12.2.2.1 Law/Regulation

#### (1) Road Law

Usually, essential matters are stipulated in the basic laws covering roads, such as the “Road Law”. In the case of Cambodia, the appropriate legal instruments have not been enacted. The draft of the road law has been completed by the MPWT and final approval is under process.

The objectives of this law are to provide a legal framework for planning improvements and extensions to existing road networks, to classify public roads, to facilitate the development and management of such networks at appropriate levels and to regulate the activities of road transport carriers so as to facilitate the provision of efficient and economically viable transport services. The contents of the new road law are shown in Table 12-16.

**Table 12-16 Contents of New Road Law**

Chapter	Contents
1	General Provisions
2	Road Management
3	Road Infrastructure Financing
4	Role of the Private Sector
5	The Road Fund
6	Road Works Activities
7	Road Traffic
8	Road Transport
9	Penalties
10	Implementing Provisions

Source: the Study on the Road Network Development, 2006, JICA

**(2) Law on Road Traffic**

The law on road traffic was enacted in 1991. Following are the aims of the traffic law.

- 1) Raising the profile and the effectiveness of traffic safety,
- 2) Maintaining public security and social order,
- 3) Protecting public property, lives and legal interests of citizens,
- 4) Educating citizens to respect the law, and
- 5) Policing traffic rules and taking action against traffic offenders

A revision of the traffic law was enacted in 2005. The objectives of the revision were to keep roads safe for road users and improve traffic flow throughout the country. All road users have to obey the regulations mentioned in this law. The differences between the law in 1991 and the revision are as follows:

- 1) The definition of traffic and roads are described in more detail.
- 2) Chapters on traffic signs, use of vehicle lights and horn, traffic accidents, and responsibility of traffic police are added.
- 3) Clause on penalties is clarified.

The contents of the revised traffic law are shown in Table 12-17.

**Table 12-17 Contents of Revised Traffic Law**

<b>Chapter</b>	<b>Clause</b>
1	General Provision
2	Traffic Signs & Directions by Traffic Police
3	Drivers
4	Use of Vehicle Lights and Horn
5	Pedestrians and Animal Riders
6	Traffic Accidents
7	Vehicle control and Transportation
8	Responsibility of Traffic Police
9	Penalties
10	Inter-Provisional
11	Final Provision

Source: The revised traffic law.

“Maximum Load Limit of Transport Vehicles Using the Road Network in Cambodia” was agreed by the Council of Ministers, sub-decree No.744 in September 1999. This sub-decree details the load limits and sets penalties for overloading. Based on this sub-decree No.744, the overload control committee inspects overloaded vehicles by fixed weigh stations provided on 1-digit roads and by mobile portable weigh scales.

### 12.2.2.2 Overloaded Vehicle Inspection

Table 12-18 shows the present development situation of fixed weigh stations managed by the MPWT and Police.

**Table 12-18 Fixed Weigh Station**

Road Number	Number of Weigh Station	Location
1	3	Prek Aeng Kg. Phnom Bavet
5	3	Kon Damrey Klaing Moeung Longvek
6	2	Puok Thnal Keng
7	1	Thanl Totoeung
Total	9	

Source: Explanatory Power Point material of “Situation of Overload Control and Future Action Plan”, ADB and JICA, Aug.2011

A total of 9 weigh stations were developed on 1-digit roads by support of ADB and JICA. A construction plan exists for 10 weigh stations mostly on 1-digit roads.

Table 12-19 shows the result of overloaded truck inspections. More than 60,000 trucks were inspected between January and July in 2011. Of these, 544 trucks were found hauling overloaded cargos. This is about 1% of the total.

**Table 12-19 Result of Overloaded Truck Inspections (2011)**

Inspection Month	No. of Inspected Trucks	No. of Overloaded Trucks	%
January	3,463	38	1.10
February	3,814	50	1.31
March	8,445	89	1.05
April	9,933	93	0.94
May	10,894	86	0.79
June	11,518	101	0.88
July	12,044	87	0.72
Total	60,111	544	0.90

Source: Explanatory Power Point material of “Situation of Overload Control and Future Action Plan”, ADB and JICA, Aug.2011

A total of 38 mobile portable weight scales are also provided at the MPWT mainly to cover 2- and 3-digit roads connecting to the 1-digit roads mentioned above. Of the 38, only 18 mobile portable weight scales are operable. The remaining 20 are out of order.

The MPWT and police try to control overloaded vehicles for safety and security of road infrastructures, the drivers and operators.

However, some overloaded trucks use roads having no weigh station such as provincial roads to avoid paying penalties and fines. This sometimes causes damage not only to the roads but also the bridges especially temporary bridges such as bailey and steel bridges.

Two weigh stations exist on NR4 which is maintained by AZ.

### **12.2.2.3 Guidelines/Manuals**

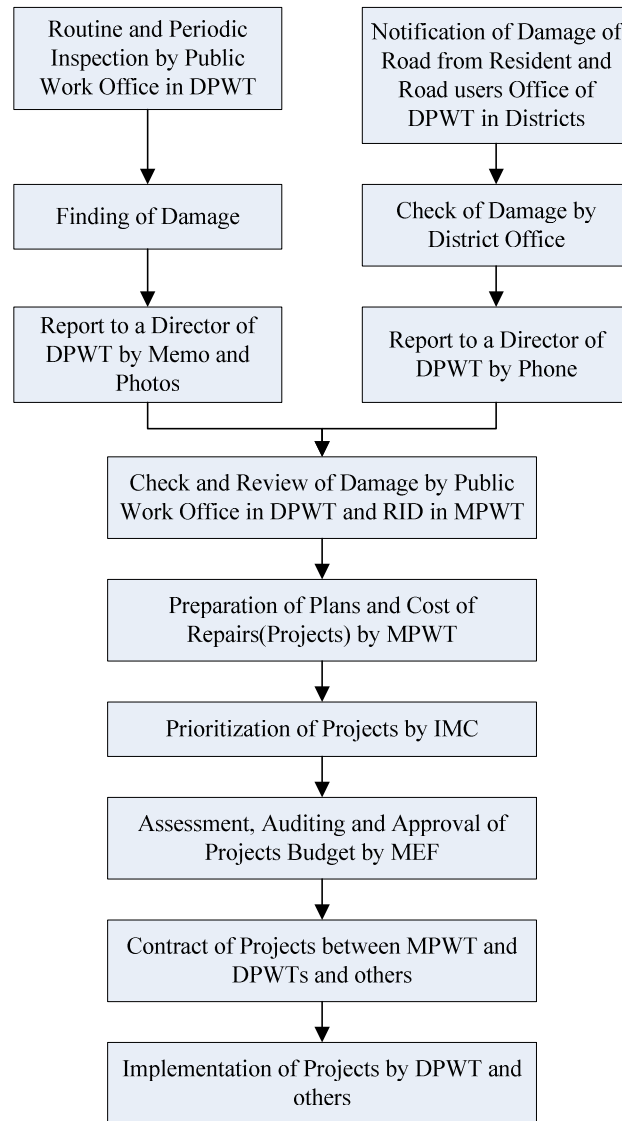
No guideline or manual for maintenance (inspection and repair) of bridges have been provided yet in Cambodia.

### **12.2.3 Bridge Management System (BMS)**

At present, bridge maintenance in Cambodia is carried out along with road maintenance. Therefore, in order to understand the BMS, we must first present an overview of the road management system and an outline of the current RAMP.

#### **12.2.3.1 Road Management System in Cambodia**

Figure 12-13 shows the flow of the management of roads and bridges in Cambodia. This is based on an interview with the DPWT (Kandal). As shown in the figure, first the damage which may hinder traffic or require large-scale repairs is identified and then the plans are made for maintenance and repair in the following year. Maintenance is not performed on the basis of medium- and long-term plan. On the other hand, currently the RAMP aims at planned road maintenance.



Source: Interview with the DPWT (kandal)

**Figure 12-13 Flow of Maintenance/Repair Works of Roads and Bridges**

**(1) Road Inventory**

Table 12-20 shows the road inventory items collected by the RAMP. It includes items regarding the main parts of a road, pavement, drainage and road structure. As the main parts of a road, the width of shoulder, shoulder condition, number of lanes and damage and condition at intervals of 200m by are collected visual survey. For the pavement, the kind of pavement, pavement width, flatness, condition and the results of pavement bedding capacity test by falling weight deflect meter (FWD) survey are collected. Condition of drainage by visual survey, video recording, overloaded vehicles and traffic volume, are collected. The structure inventory records for the road assets data base are collected even though there are considerably fewer items required for the BMS.

**Table 12-20 Road Inventory Items Collected by the RAMP**

Items					
Road	Road ID, Link ID, Station, No. of lanes, Damage, Shoulder width, shoulder condition, Weigh in motion, Traffic data, Video Capture				
Pavement	Kind of Pavement, Pavement width, flatness, Pavement condition Test result of FWD				
Drainage	Drainage condition				
Road Structure	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; width: 15%;">Bridge</td> <td>Bridge ID, Bridge name, Construction year, Province, Bridge type, Road number, Link ID, Station, No. of spans, Clear height, Clear width, Load limit, Services, Crossing type, Deck width, Surface material, Deck condition, Guardrail type, Guardrail condition, Abutment type, Abutment condition, No of piers, Pier condition, Expansion joints, Road signs, Erosion protection, Photos</td> </tr> <tr> <td style="text-align: center;">Culvert</td> <td>Culvert ID, Construction year, Province, Road number, Link ID, Station, Culvert type, No. of cells, Pipe diameter, Cell size, Road width, Condition, Headwall type, Condition, Upstream and downstream channel, Erosion protection, Erosion protection condition, Photos</td> </tr> </table>	Bridge	Bridge ID, Bridge name, Construction year, Province, Bridge type, Road number, Link ID, Station, No. of spans, Clear height, Clear width, Load limit, Services, Crossing type, Deck width, Surface material, Deck condition, Guardrail type, Guardrail condition, Abutment type, Abutment condition, No of piers, Pier condition, Expansion joints, Road signs, Erosion protection, Photos	Culvert	Culvert ID, Construction year, Province, Road number, Link ID, Station, Culvert type, No. of cells, Pipe diameter, Cell size, Road width, Condition, Headwall type, Condition, Upstream and downstream channel, Erosion protection, Erosion protection condition, Photos
Bridge	Bridge ID, Bridge name, Construction year, Province, Bridge type, Road number, Link ID, Station, No. of spans, Clear height, Clear width, Load limit, Services, Crossing type, Deck width, Surface material, Deck condition, Guardrail type, Guardrail condition, Abutment type, Abutment condition, No of piers, Pier condition, Expansion joints, Road signs, Erosion protection, Photos				
Culvert	Culvert ID, Construction year, Province, Road number, Link ID, Station, Culvert type, No. of cells, Pipe diameter, Cell size, Road width, Condition, Headwall type, Condition, Upstream and downstream channel, Erosion protection, Erosion protection condition, Photos				

Source : RAMP final inception report 2010

## (2) Relationship between Road Inventory and Bridge Inventory

The bridge inventory is created by two projects. One is the RAMP and the other is the Study.

The RAMP is creating a bridge inventory for registration of assets. However, for the BMS the number and kinds of items recorded in the bridge inventory are inadequate. But the RAMP inventory will be created for all bridges that are managed by the MPWT and the information that it contains will be very useful for the Bridge list.

The Study creates a bridge inventory for the prioritization of reconstruction of temporary bridges. The number and kinds of items that are recorded in that bridge inventory are very useful for the BMS of temporary bridges, but it wasn't carried out for all of the bridges managed by the MPWT. In any case, for the BMS of permanent bridges the number and kinds of items recorded in this bridge inventory are also inadequate, therefore, for the BMS of temporary bridges additional research will be needed.

### 12.2.4 Budget and Expenditure for Bridge Maintenance

#### 12.2.4.1 Budgeting System

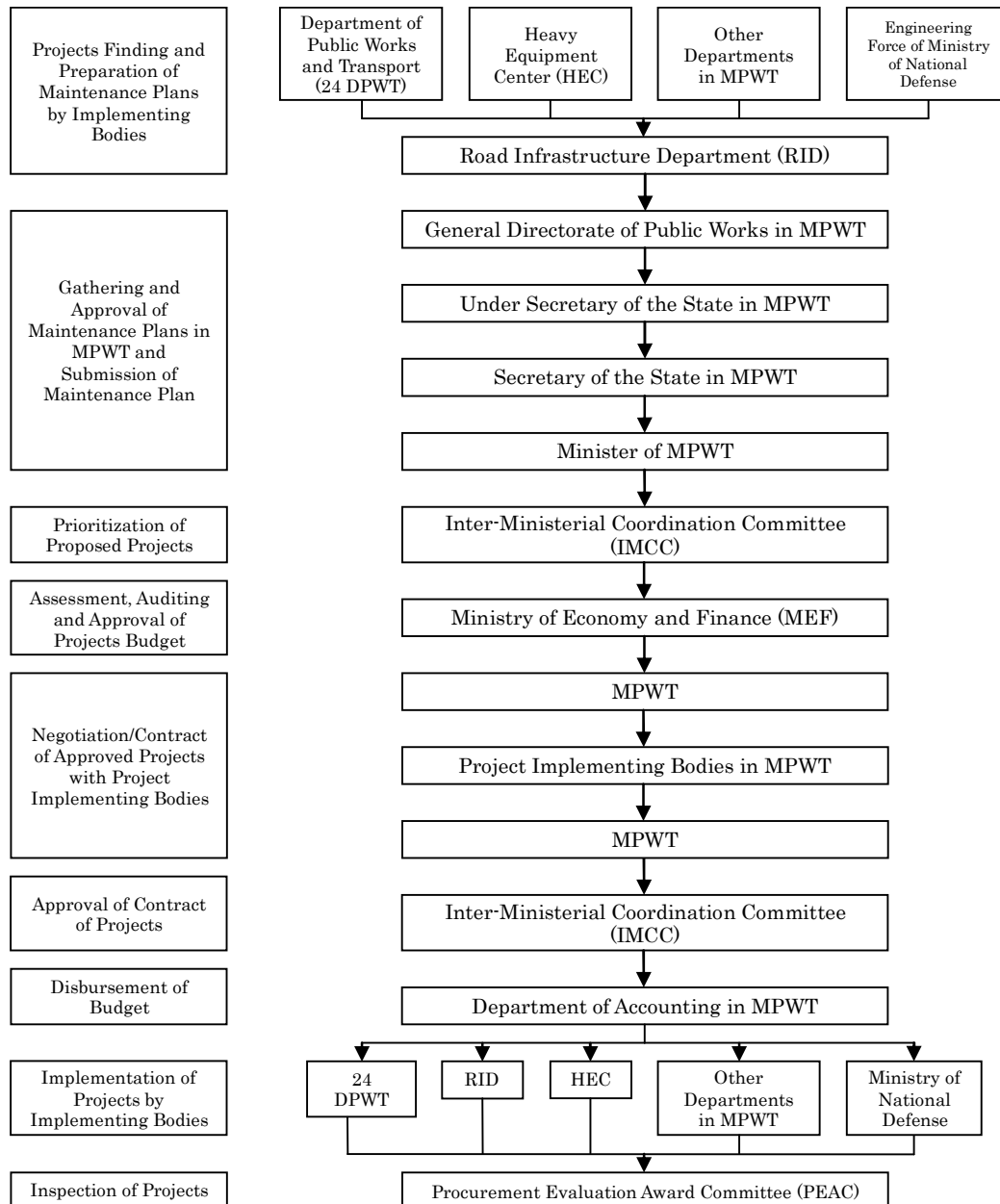
A single year budget system is applied in Cambodia. The financial year in Cambodia starts in January and closes at the end of December. Each Ministry has to prepare a request for the next year's budget in July and negotiate with the MEF in September. The MEF provides a draft budget report in November. The draft is submitted to the Cabinet and is approved in November. Finally, the national assembly approves the budgets in December.



The items in the budget request to the MEF consist of salaries and allowance, administrative expenses, economic activity support expenses, social welfare and culture expenses, international activity expenses and investment by internal fund. Investment by internal fund constitutes more than half of the total budget.

In order to obtain the road maintenance budget, the MPWT prepares the routine maintenance program, showing the requested amount of maintenance funding and its breakdown and then negotiates with the MEF.

Figure 12-14 shows the flow of budget approval and implementation of maintenance.



**Figure 12-14 Flow of Budget Approval and Implementation of Bridge Maintenance**

### 12.2.4.2 Annual Budget and Expenditures

The allocated budget amounts for the MPWT from 2006 - 2010 (expenditure based) are shown in Table 12-21. Expenditure amounts have been increased year by year. Total expenditures for maintenance costs reached more than 80 million US dollar in 2010. This is more than 2.5 times the expenditure of year 2007. Table 12-21 shows a summary of budget of year 2011. Nearly 100million US dollar was budgeted for maintenance cost of roads and bridges. Expenditures and budget for reconstruction of roads and bridges occupies more than half of the total. Moreover, more expenditure is used and more budgets are allocated for repair of roads and road-related furniture than repair of bridges.

According to Table 12-22, the DPWTs are the implementing bodies of routine and periodic maintenance, up-grading and reconstruction, and emergency works. The RID is an implementing body of periodic maintenance and up-grading and reconstruction, and a supervisor of routine and periodic maintenance, and up-grading and reconstruction. The HEC is an implementing body of up-grading and reconstruction works and PWRC supervises up-grading and reconstruction works.

**Table 12-21 Comparison of Initial Budget and Implemented Budget for Road Maintenance and Construction (Year 2006 ~ 2010)**

Budget Category			2006	2007	2008	2009	2010
1	Routine Maintenance	Initial	2,500,000	5,731,707	8,809,524	17,142,857	17,857,143
		Implemented	2,400,000	5,380,000	9,250,000	14,300,000	16,300,000
2	Periodic Maintenance	Initial	-	12,195,122	14,285,714	13,285,714	15,000,000
		Implemented	-	23,280,000	15,000,000	68,120,000	17,010,000
3	Re Construction	Initial	-	8,926,826	11,904,762	45,238,095	45,238,095
		Implemented	-	Included in 2	Included in 2	Included in 2	44,380,000
4	Flood Works (Special)	Initial	-	2,439,024	2,380,952	-	-
		Implemented	-	2,180,000	0	-	-
5	Emergency	Initial	-	1,585,366	1,904,762	2,380,952	2,857,143
		Implemented	-	853,000	2,000,000	2,500,000	2,850,000
Total		Initial	2,500,000	30,878,049	39,285,714	78,047,619	80,952,381
		Implemented	2,400,000	31,690,000	26,250,000	84,920,000	80,540,000

Source: Initial Budget from Presentation Data on Road Maintenance and Construction Year 2011, the RID, The MPWT and Implemented Budget from Project List of the MPWT

**Table 12-22 Summary of Planned Budget of Year 2011**

Budget Category	Planned Budget (USD)	Project	Implementing Body	Supervision	Scope of Work
Routine Maintenance	16,097,561	25	24 DPWTs/ Municipality	Office of Inventory and Maintenance of Roads and Bridges in RID	NRs, PRs and Bridges Maintenance Regular Inspection (6times/year) Traffic Count
Periodic Maintenance	26,585,366	56	24 DPWTs/ Municipality, and Road Unit in RID	Office of Technical Planning of Road and Bridge in RID	Road (NRs, PRs) pavement, Bridges and Structures Repair Road Furniture Painting & Installation
Up Grading and Re-construction	50,000,000	54	17 DPWTs/ Municipality, RID, HEC, 5 Military Engineering Units, others	Office of Technical Planning of Road and Bridge in RID, Public Works Research Center	Up grading and re-construction of NRs, PRs bridges and other structures (including 68 locations - 1,815m of total length - of concrete bridges)
Emergency	3,658,537	29	24 DPWTs/ Municipality	Emergency Technical Group from MPWT and MEF	Roads: 9 Bridges: 18 Culverts: 2
Total	96,341,463				

Source: Presentation Data on Road Maintenance and Construction Year 2011, RID, MPWT

#### **12.2.4.3 Source of Funding for Bridge Maintenance**

Funds for the maintenance works are procured by application to the MEF, which is responsible for providing these funds. The MEF disburses the required funds from the road development fund, which is under the joint control of the Prime Minister's Office and the MEF. At present, the source for the road maintenance fund is the Added Tax on gasoline (Road User Special Tax) as prescribed in a PRAKAS, sub-decree in Cambodia, in 2002, but the fund is inadequately managed in spite of the prescription in the aforementioned decree.

##### **(1) Road User Special Tax (Added Tax)**

This is a special fund introduced in 2002 as an Added Tax aiming at the promotion of road maintenance. The taxes on purchasing fuel; 2 cent/liter for gasoline and 4 cent/liter for diesel, are charged to fuel importers. This fund is under the administration of the MEF and the Prime Minister's Office.

##### **(2) Road User Tax**

This tax was introduced in 2002. 100,000 Riel (USD25) is being charged per annum. This tax is not a special fund for road maintenance at present but it is directly related to road users.

##### **(3) The Fund for Road Maintenance and Repair (FRMR)**

###### **1) Inter-Ministries Prakas of June 28, 2000 on Formation of the FRMR**

The FRMR shall be used for the routine and periodic maintenance and repair of national, provincial and rural roads that are under the management of the MPWT, the MRD and other

road authorities. The FRMR cannot be used for anything other than repairing and maintenance of roads. (Inter-Ministries Prakas of June 28, 2000)

- 2) Sub-Decree of May 6, 2002 on Transferring of the Management of Budgetary Credit

The management of the FRMR shall be transferred to be under the direction of the Prime Minister and the MEF. (Sub-Decree of May 6, 2002)

- 3) Circular of October 2, 2003 on Procedure and Law of Using the FRMR

The government established an order to collect road user tax on fuel at USD 0.02/liter and diesel at USD 0.04/liter to fund the routine maintenance and periodic repair of rural, provincial and national roads that are stipulated by the Financial Law Management in 1999. The Road Authorities have to make application for budgets for implementing maintenance works each year. The IMC will review and evaluate the results of each project. (Circular of October 2, 2003)

### **12.2.5 Review of the Past Projects/Programs**

A review of the past four projects related to bridge maintenance should be undertaken in order to determine the problems that could arise for the implementation of bridge management projects in the future.

#### **(1) The Study on Road Network Development, 2006**

The purpose of the road network development plan was as follows.

- 1) To formulate a road development master plan covering the whole country of Cambodia with a target year of 2020, including the study of the institutional development of road maintenance;
- 2) To carry out a pre-feasibility study for selected high priority projects; and
- 3) To undertake a transfer of knowledge and technology.

The road network development plan produced in this project is shown in Figure 12-15. That plan was made incorporating the development strategy as shown in the following.

##### 1) Multi growth pole development

To contribute to multi core national development instead of that of sole initiative by Phnom Penh.

##### 2) National integration

To contribute to the national integrity and administration for remote areas where road access is very limited.

##### 3) Development of the international corridor

To contribute to an expansion of trade and commodity flows to and from neighboring countries

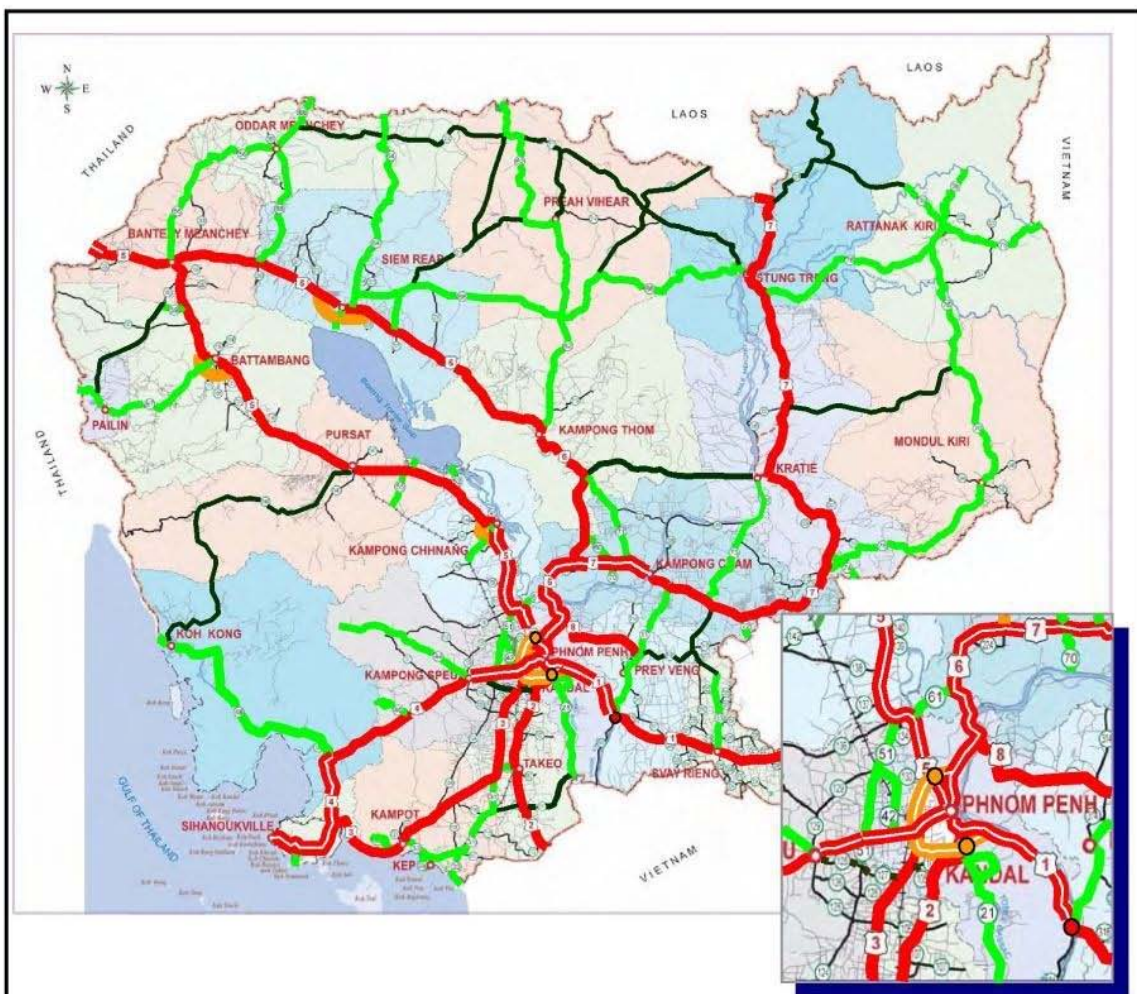
##### 4) Enhancement of rural economic development

To contribute to promotion of regional industries, an expansion of investment and an increase in employment

5) Regional development for poverty reduction

To contribute to the enhancement of Basic Human Needs (BHN), employment, education, safety and health.

In order to achieve the development plan, establishment of a Sustainable Road Maintenance System has also been proposed.



ROAD NETWORK DEVELOPMENT PLAN

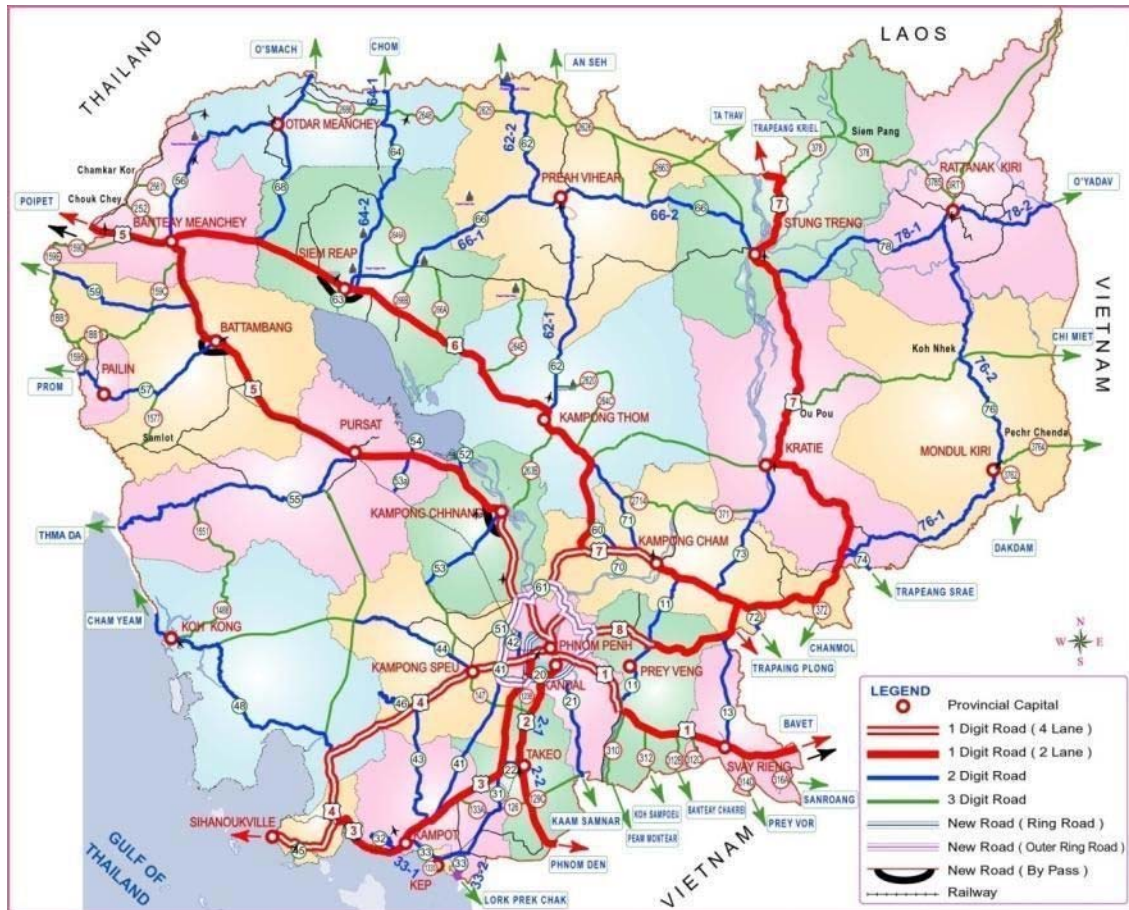
ROAD CLASSIFICATION		SECTION TO BE IMPROVED		MAINTENANCE WORK ONLY	TOTAL	
1-DIGIT NATIONAL ROADS		4-LANE	455km	0km	2,052km	
		2-LANE	1,597km	0km		
2-DIGIT NATIONAL ROADS			2-LANE	2,643km	2,643km	
PROVINCIAL ROADS			2-LANE	1,554km	5,061km	6,615km
RURAL ROADS			2-LANE	0km	18,948km	18,948km
NEW ROADS	RING ROAD		4-LANE	50km	0km	50km
	BYPASSES		2-LANE	80km	0km	80km
NEW BRIDGES		 	2-LANE	3km.	0km	3km
TOTAL						30,391km

Source: The Study on the Road Network Development in the Kingdom of Cambodia 2006

Figure 12-15 Road network development plan 2006

(2) **The Follow up Study on the Road Network Development Master Plan , 2009**

Through the master plan, the road network development plan was changed as shown in Figure 12-16.



Source: Follow up study on the road network development master plan, 2009

**Figure 12-16 Road network Master plan 2020**

As for the development strategy, the following two activities were added to it in 2006.

- a) Strengthening of economic growth corridor development.
- b) Promotion of tourism development.

The following recommendations have been made in regard to the road maintenance (2009) Follow-up study.

- 1) Strengthening the collection of basic data on road maintenance
  - A nationwide traffic survey, Axle load survey and update of the road inventory are needed.

2) Strengthening of Organization to implement Road Development, Maintenance and Operation

It is necessary to establish an organization with a consistent budget in the MPWT to implement road development and maintenance and operation strategically, accompanied with capacity building both to effectively enhance the road administration and to enhance road maintenance/operation, road construction supervision, administration of construction material and equipment, and quality control, for the MPWT and private road construction companies.

At present, issue 1) has been improved by the RAMP and the Study. Various data collection is possible through the implementation of traffic surveys, etc. and thereby understanding of traffic volume and vehicle axle loads becomes possible. The road inventory is scheduled to be reconstructed by the RAMP

However, “Strengthening of Organization to implement Road Development, Maintenance and Operation” is only a plan at present.

Progress of the master plan is shown in Table 12-23. The 1-digit roads to which priority are given have been omitted. For short-term plan expected to be completed in 2013, 13 routes out of 17 routes are completed or are on-going. For medium/long-term plan, 11 routes of 29 projects are completed or are on-going. Progress which exceeds the plan is seen.



**Table 12-23 Progress of road network development plan**

	Road No.	Length (Km)	Number of Bridge	Condition			Progress	
				Follow Up Study	MPWT List	Survey		
1	31	54.81	6	Short Term	On-going by Korea		○	2009~ 2013 10/13
2	33	52.27	12	Short Term	ADB Bidding		○	
3	57	103.34	19	Short Term	On-going by China	Completed	○	
4	62	242.66	28	Short Term	Completed /On-going by China	Completed	○	
5	72	13.50	1	Short Term		Completed	○	
6	73	92.40	16	Short Term			○	
7	78	193.96	13	Short Term	Completed by Vietnam and China.	Completed	○	
8	159D	20.63	6	Short Term		Completed	○	
9	312	28.66	1	Short Term		Completed	○	
10	312B	22.09	1	Short Term		Completed	○	
11	314D	25.67	1	Short Term			×	
12	2648	63.31	-	Short Term			×	
13	59		-	Short Term			×	
14	11	90.28	18	Short-Mid Term	Japan (Proposing)		○	6/14
15	56	113.62	19	Short-Mid Term	ADB /Korea Bid prepa.	On-going	○	
16	68	117.68	31	Short-Mid Term	On-going by Cambodia	Completed	○	
17	76	306.18	47	Short-Mid Term			×	
18	378	79.01	7	Short/Mid Term		Completed	○	
19	1488	75.00	5	Short/Mid Term			×	
20	1551	41.17	13	Short/Mid Term			×	
21	2624	78.95	4	Short/Mid Term			×	
22	13	45.60	8	Mid Term			×	
23	41	96.45	16	Mid Term	On-going by China	On-going	○	
24	43	78.88	35	Mid Term			×	
25	264C	70.72	3	Mid Term			×	
26	264E	57.32	9	Mid Term		On-going	○	
27	2620	29.68	6	Mid Term			×	
28	53	49.15	11	Mid-Long Term			×	5/13
29	55	185.20	116	Mid-Long Term	China loan under nego.		○	
30	59	117.99	12	Mid-Long Term	On-going by China	On-going	○	
31	21	65.56	66	Long Term	Korea Loan Requested		○	
32	42	24.26	6	Long Term			×	
33	44	84.84	13	Long Term	China F/S under nego.		○	
34	46	26.99	4	Long Term			×	
35	60	19.94	-	Long Term	On-going by ADB?		○	
36	66	133.87	39	Long Term		Completed	×	
37	126	16.39	1	Long Term			×	
38	129C	2.21	1	Long Term			×	
39	147	34.61	4	Long Term			×	
40	371	89.51	10	Long Term			×	

Source : Study Team

**(3) Bridge Structure Inspection Introductory Training by New Zealand ODA Program in 1997**

Training has been conducted for the purpose of improving the management capacity for bridge maintenance. Implementation of the training was intended to meet the request of the Cambodia and the purpose of the project.

Training courses have been the most effective setting possible for participants who have some degree of technical sophistication and moderate English proficiency. Table 12-24 shows the contents of the course.

**Table 12-24 Contents of training course**

WEEK	CONTENT	TOPIC	DETAIL
1	Introduction	Introduction to Inspection	Overview of Inspection Requirements
		Basic Design	Overview of Basic Design Concepts
		Deterioration of Structures	Overview of Various Mechanisms of Deterioration
		General Inspection Principals	Principals of Inspection and Measurement -Various Materials
		Inspecting Steel	Aspect Specific to Steel Structures
2	Detailed Inspection	Inspecting Steel	Aspect Specific to Steel Structures
		Inspecting Concrete	Aspect Specific to Concrete Structures
		Inspecting Wood	Aspect Specific to Wooden Structures
		Weld Inspecting/Testing	Details Specific to Welds, Introduction to testing
		Photographic Theory	Use of Cameras /film/lighting, camera operation
3	Documentation	Photographic Reporting	Logging of photographs, Composing photographs, practical
		Planning Inspection	Methods of considerations of planning
		Design and Use of Datasheets	Principal datasheet design and use, Practical exercises
		Reporting Inspections	Compiling reports, essential aspects, anomaly based reporting, practical exercises
4	Bridges	Bridge Inspections	Detailed application of principals with respect to bridges
5	Practical	Applied Inspections	Principal inspection exercises in the provinces

Source: Bridge Structure Inspection Introductory Training 1997 by NZ

Course features of education in the project are as follows.

- 1) Basic structural mechanics, basic bridge design, overview of the degradation mechanism of the structure and etc. Content is to confirm the basics of structural engineering.
- 2) Training has been conducted for the inspection of each material. The training includes Materials Science, Engineering, manufacturing, construction and, etc., contents of which are covered in the general training material.

- 3) Highly accurate inspection methods have been presented. For example, Bailey bridges had been proposed for inspections to be carried out for every single material and records kept for each material, which produces an inspection method with high accuracy. However this type of inspection and record keeping takes a lot of effort and the load is greater for the implementation of these inspections.

Based on the interview with the MPWT, it is hard to say that this Project mentions the effect on the present condition of the periodical inspections that are supposed to be using the intensive inspection format mentioned above. But these inspections have not been carried out and no inspection records are kept. It is considered that one of the causes for the lack of inspections and records is that this is a heavy burden on the implementation of inspections.

In addition, the course content is highly complex. It had started out designed for the general maintenance of bridges targeted engineers who can oversee the maintenance of the bridges. It would be too highly functional for basic inspector training.

In the future, in the implementation of Project-related bridge maintenance it will be necessary to pay attention to the following matters.

- a) The method of inspection, conditions such as staff assignments, budget, and propriety of out sourcing must be determined and it must be a method of inspection which can be implemented.
- b) The implementation of the training must be centred on the purpose of the training and a prospective participant's capability, and it must propose the most effective method.

**(4) Strengthening of Construction Quality Control Project by JICA from 2009 to 2012**

The quality control project is being carried out for the following four purposes.

- 1) Preparing and implementing of Standard Guidelines & Regulations for force account projects
- 2) Collecting the past documents and establishing document database systems for past completed projects.
- 3) Implementing technical training for quality control by the MPWT, for roads, bridges and culverts.
- 4) Establishment of standard drawings for roads, bridges and culverts.

The part of the project directly related to the maintenance of bridges underlines the above four purposes. The submissions to the MPWT for the “documents and establishing a document database system for past completed projects” and ”standard drawings for roads, bridges and culverts”, have been completed.

Table 12-25 shows the List of items that have been collected for the “document data base system for past completed projects” by the quality control project. The bridges that are included in the inventory are limited to the bridges on 1- digit roads and constructed since

2003. Most 2-digit roads are not included. There is a limit regarding data collection from the past projects.

**Table 12-25 List of items collected for the data base**

Material name	Road Number	Construction Year	Number of Bridges			Summary
			Over 200m	Others	Total	
NR5 As-built drawingpk83+600- PK171+000 221+100 -357+100	5	2003		45	45	
EDCF Loan No. KHM-3 Kampot-Traapang Ropaou road rehabilitation Project (Bridge)	3	2007	1	13	14	New Campot Bay Bridge (M) L=240m
GMS Phnom Penh - HO Chi Minh City Highway Project Bridges nr-1	1	2003		7	7	
PC Hollow Slab by Uy Sophal 08182011 NR-1	1	2011	1	1	2	bassac bridge(C) L=855m
Package 5F,6E,6F NR6 simriap	6	2005		37	37	ADB
1 Asian Development Bank Loan No 1969 Part A (II) PK0+000 - PK3+160	-	-		2	2	Road and Bridge to Genocide Memorial
Cambodia Road improvement project	6	2008		39	39	
Ministry of Public Works and Transport New Bridge and STA 143 Route No48	48	2007		1	1	
Rehabilitation Project of National Road No.7 of Cambodia from Kratie to the Border between Cambodia and Laos Volume of 5 Book 2 of 3	7	2007		9	9	
Rehabilitation Project of National Road No.7 of Cambodia from Kratie to the Border between Cambodia and Laos Volume 3 of 5 Book 1 of 3	7	2007	1		1	Secong River Bridge(C) L=1005.7m
Rehabilitation National Road No 7 Kompong Cham	7	2003		3	3	
Rehabilitation of National road No.2 Bridge No 1 to5	2	2006		5	5	
The Project for Improvenent of Bridge National Highway Route 6A Bridge No.24 and No.25	6	2003		2	2	
The Project for Improvenent of Bridge on National Highway Route 6A	6	2002		1	1	
The Project for the Improvenent of the National Road No.1	1	2007		2	2	Flood control
Total			3	164	167	

Source: the Strengthening of Construction Quality Control Project

In the preparation of the Bridge Inventory, the use of the "Data Base System for Past Completed Projects" is very effective. For permanent bridges that required many kinds of items for bridge inventory, it is particularly effective. In order to make as much use of this as possible, storing the data on the data base certainly is important for the BMS.

Moreover, when planning the reconstruction of temporary bridges, practical use of "Standard Drawings for Bridges" is effective.

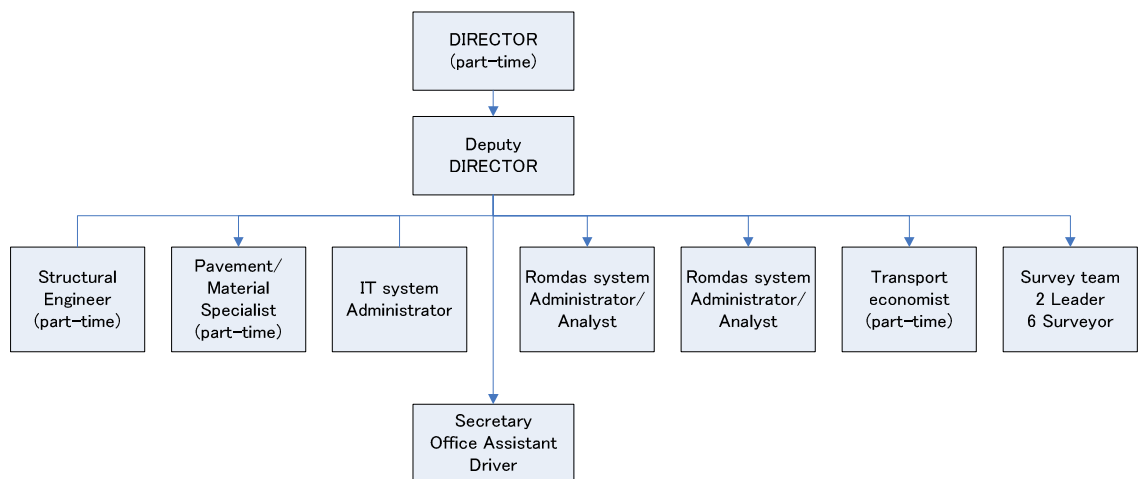
(5) Road Asset Management Project (RAMP)

The RAMP has been carried out since 2008 for the implementation of the planned maintenance of the roads. The purpose of the RAMP is to conduct the following three activities, as is indicated in the Road Asset Management Project Final Inception Report, 2010.

- 1) Improvement of the capacity of the road management in Cambodia.
- 2) Establishment of the road inventory.
- 3) Implementation of the Road Asset Management

Methods of road maintenance in the RAMP include data collection by Road Measurement Data Acquisition system (ROMDAS) and planning of road management using Asset Management System (HIMS).

Road Data Collection Management Unit (RDCMU), which was organized by the MPWT personnel, has carried out data collection by the ROMDAS and plans the road management plan using the HIMS. They have received training in technological know-how and all of this has improved their road management capacity. Figure 12-17 shows the organization of the RDCMU.



Source : RAMP final inception report, 2010

**Figure 12-17 RDCMU Organization**

The role of RDCMU includes the following three activities.

- a) Maintain the Road Decision and Management System (RMDS)
- b) Collect the data required for the MPWT.
- c) Prepare an annual report for the MPWT.

The road inventory is created mainly by the ROMDAS. Table 12-26 shows the contents of the data collection.

**Table 12-26 Road Inventory data collected by PAMP**

Item	Contents
ROMDAS data collection	<p>The following data is collected by a run of a specially equipped vehicle.</p> <ul style="list-style-type: none"> <li>• Road Inventory Attributes, including video capture</li> </ul> <p>Pavement condition</p> <ul style="list-style-type: none"> <li>• Road centerline using GPS</li> <li>• Transversal Profile Logger</li> </ul> <p>Pavement type, Pavement width, holder type, Shoulder width, traffic lanes</p> <ul style="list-style-type: none"> <li>• Roughness</li> <li>• Visual inspection for 200m sections</li> </ul> <p>Major defects, Drainage, Shoulders, Rutting</p> <ul style="list-style-type: none"> <li>• Moving traffic survey</li> </ul>
Structure inventory	<ul style="list-style-type: none"> <li>• Bridge and Culvert Inventory</li> </ul>
FWD survey work	<ul style="list-style-type: none"> <li>• FWD (falling weight deflect meter)</li> </ul> <p>non-destructive testing of pavement bearing capacity by measuring the deflection of a falling weight.</p>
Weigh in motion and Traffic data	<ul style="list-style-type: none"> <li>• Measurement of overloaded vehicles, traffic survey</li> </ul>

Source : RAMP final inception report 2010

Collection Data is stored in the HIMS and a road maintenance plan is drawn up.

Table 12-27 shows the progress of the ROMDAS Survey in the 2010

**Table 12-27 Progress of ROMDAS Survey 2010**

Road classification	Progress (km)	Completed (%)
National Road (Paved)	1,765/2,073	85%
Other National/Secondary (Paved)	1,270/1,270	100%
Other National/Secondary (Unpaved)	63/1,956	3%
Provincial (Paved)	517/517	100%
Provincial (Unpaved)	263/5,654	5%
Total	3,878/11,470	34%

Source : RAMP final inception report, 2010

Progress in 2012 is 60% of ROMDAS survey and structure survey has been started. (Interview with RDCMU) Road management and bridge management are inseparable, the relationship between the RAMP and the BMS is very strong. It is desirable for this work to continue together in the same organization.

The RAMP and bridge management handle the same type data, therefore, it should be sufficient to adjust the relationship between them during future implementation of the BMS. Efficient division of roles and unity of the common issues should be sought.

a) Unification of the Bridge Inventory

In the creation of the Bridge Inventory it should be unified with the Bridge Inventory created by the RAMP. In addition, the basic elements such as route number, must be consistent with those used in the road inventory made by the RAMP,

b) Integration of the survey items

For working on common research topics such as traffic analysis, integration of the data from the RAMP and the BMS will avoid unnecessary investigation.

c) Priority for road maintenance

After determining the priority of unpaved roads for road asset management, reflect the result in the BMS for temporary bridges.

### 12.3 Problems and Issues on Bridge Maintenance

The Study Team conducted interviews with many persons involved in bridge maintenance in the MPWT, the DPWTs, education sector and private companies. The Study Team also collected information and data on bridge maintenance. Following are problems found based on those interviews and analysis of the information/data obtained. Problems can be classified into 6 fields – condition of roads and bridges, organization, inspection technology, information and data, human resources, and others. Table 12-28 shows the problems by field.

**Table 12-28 Problems on Road and Bridge Maintenance**

<b>Fields</b>	<b>Problems</b>
Condition of Roads and Bridges	<ul style="list-style-type: none"> <li>• Only minor repair of bridges is carried out.</li> <li>• Replacement of bridges is put at a higher priority than repair works.</li> <li>• Budget for bridge maintenance is low.</li> <li>• Condition of bridges especially temporary bridges is not good.</li> </ul>
Organization	<ul style="list-style-type: none"> <li>• RID, HEC and each DPWT construct roads and bridges.</li> <li>• Each DPWT carries out regular inspection of roads and bridges.</li> <li>• RID and HEC conduct a detailed survey and planning of repair based on inspection results.</li> <li>• No organization responsible for construction, investigation and repair has been established yet.</li> <li>• Information and data of constructed roads and bridges have not been managed by one organization in the MPWT.</li> <li>• Only about 60% of proposed projects were approved by MEF.</li> <li>• The MPWT and DPWTs have maintained all of the national and provincial roads and bridges on the roads except National Road No. 4.</li> </ul>
Inspection Technology	<ul style="list-style-type: none"> <li>• Only visual inspection has been carried out.</li> <li>• Inspection results have been noted.</li> <li>• No common inspection sheet has been developed.</li> <li>• Inspection results/data has not been kept and not recorded.</li> <li>• No guideline or manual for inspection and repair has been developed.</li> <li>• Inspection work is not understood well.</li> <li>• Training for inspection work has not been done.</li> </ul>

Information and Data	<ul style="list-style-type: none"> <li>• RID and HEC have different lists of roads and bridges.</li> <li>• Items and contents of the lists are different.</li> <li>• Number of bridges in the lists is different.</li> <li>• Data of the list is old and information on condition is not explained properly.</li> <li>• Form of the lists is different.</li> <li>• No network has been developed for access to the list.</li> </ul>
Human Resource	<ul style="list-style-type: none"> <li>• Staff having knowledge, skill and experience of inspection is very few.</li> <li>• Number of staffs in each DPWT is decreasing.</li> <li>• Many staffs in the MPWT and DPWTs do not get enough salary.</li> <li>• Only a small number of university students want a job in a public sector.</li> <li>• Only a small number of high-school students want to go enter engineering universities or engineering departments in universities.</li> <li>• Tuition fees of universities and departments of engineering are higher than others.</li> <li>• No scholarship system is provided by the government.</li> <li>• Course contents on structural engineering in the university are out dated.</li> <li>• Classroom hours on structural engineering are inadequate.</li> <li>• Teachers have jobs other than at a university.</li> </ul>
Others	<ul style="list-style-type: none"> <li>• Taxes founded and collected for road and bridge maintenance have not been used only for the maintenance but also for other purposes.</li> <li>• Rate of taxes is rather low.</li> <li>• Regulatory work against overloaded vehicles is lax.</li> <li>• Overloaded vehicles avoid measuring points.</li> <li>• Only 7 measuring points for overloaded vehicles exists in Cambodia.</li> <li>• Collapse of bridges has occurred due to overloaded vehicles.</li> </ul>

Source: Study Team

## **12.4 Proposal of the Framework for Capacity Development of the Bridge Maintenance**

### **12.4.1 Problem Analysis and Objective Analysis**

Based on problems found in Chapter 12.3, problem analysis and objectives analysis are carried out.



Problems Analysis

Effects	Causes/Effects	Causes/Effects	Causes/Effects	Causes
Roads and Bridges in Cambodia are not maintained properly.	Roads and Bridges managed by the MPWT are not maintained properly.	Capacity on road and bridge maintenance of the MPWT is low/inadequate.	1. Organization for maintenance is not clear.	1-1 No special organization for maintenance exists. 1-2 Roles, responsibilities and authority on maintenance are not clear. 1-3. Information and data are not managed by one organization.
			2. Technology of maintenance is not developed.	2-1 No maintenance guideline is developed. 2-2 No maintenance manual is also developed. 2-3 Visual inspection is carried out.
			3. Capability of engineers on maintenance is low.	3-1 Engineers do not understand maintenance work well. 3-2 No training for maintenance is implemented. 3-3 Engineers have little experience, knowledge and skill. 3-4 No qualification system for an inspector is developed.
			4. No maintenance management system is developed.	4-1 No network is developed. 4-2 Different data is managed by organizations. 4-3 Contents of data is not adequate. 4-4 System including evaluation of inspection result, study of alternatives, planning of repair and cost estimate has not been established yet.
		Insufficient budget for road and bridge maintenance is secured.	1. Funding source for road and bridge maintenance is not adequate.	1-1 Number of existing funding sources for maintenance is few. 1-2 Tax rates of existing funding sources are lower than present scale of economy. 1-3 Maintenance work has never been outsourced to the private sector. 1-4 Some taxes collected from existing funding sources established for maintenance have been used for other purposes.
				1-1 Law/regulation on the road traffic is not enforced strictly. 1-2 Number of points for measuring weight of vehicles is few. 1-3 Number of weight measurement machines is few.
		Law/regulation on road traffic is not complied.	1. Regulatory work and penalty against overloaded vehicles is lax.	2-1 Explanation of traffic law/regulation has not been carried out. 2-2 No activities for prevention of overloaded vehicles have been conducted.
			2. No awareness activity to truck operators is carried out.	1-1 High-school students and parents of the students have bad image of engineering jobs. 1-2 Tuition fees of engineering departments and universities is higher than other universities and departments.
		Number of engineers having enough knowledge and skill is very few.	1. Few high-school students go to engineering universities.	2-1 Classroom hours each day is inadequate (around half of a day) 2-2 The most recent technology is not (can't be) taught. 2-3 Many teachers have other jobs as well.
			2. Class is not so interesting.	3-1 Salary of public sector is lower than private sector.
			3. Job in public sector is less attractive.	

Source: Study Team

Objectives Analysis

Objectives	Means/Objectives	Means/Objectives	Means/Objectives	Means
Roads and Bridges in Cambodia are maintained properly.	Roads and Bridges managed by the MPWT are maintained properly.	Capacity on road and bridge maintenance of the MPWT is strengthened.	1. Organization for maintenance is strengthened.	1-1 A special organization for maintenance is established. 1-2 Roles, responsibilities and authority on maintenance are clarified. 1-3 Information and data are managed by one organization.
			2. Technology of maintenance is developed.	2-1 Maintenance guideline is developed. 2-2 Maintenance manual is developed. 2-3 Tools necessary for inspection are provided.
			3. Capability of engineers on maintenance is improved.	3-1 Items of the training for road structures engineers in the MPWT and DPWTs will be studied. 3-2 Training materials, planning of the training schedule and planning of the monitoring will be prepared. 3-3 Training to engineers in the MPWT and 24 DPWTs is implemented. 3-4 Qualification system for an inspector is developed.
			4. Maintenance management system is established.	4-1 Network is developed. 4-2 Data is managed by one organization. 4-3 Contents of data is adequate and enough. 4-4 System including evaluation of inspection result, study of alternatives, planning of repair and cost estimate is established.
		Sufficient budget for road and bridge maintenance is secured.	1. Funding source for road and bridge maintenance is found.	1-1 New funding sources for maintenance are found. 1-2 Tax rates of existing funding sources is revised. 1-3 Maintenance work is outsourced to the private sector. 1-4 Taxes collected from existing funding sources established for maintenance are all used for maintenance.
		Law/regulation on road traffic is complied.	1. Regulatory work and penalty against overloaded vehicles is strengthened.	1-1 Law/regulation on the road traffic is amended. 1-2 Amended law/regulation is applied strictly 1-3 Number of points for measuring weight of vehicles is increased. 1-4 Number of weight measurement machines is increased.
				2. Awareness activity to truck operators is carried out.
		Number of engineers having enough knowledge and skill is increased.	1. Number of high-school students going to engineering universities is increased.	1-1 Image to engineering jobs is improved. 1-2 Scholarship system is established.
				2. Classes are enhanced.
			3. Attractiveness of job in public sector is increased.	3-1 Salary of public sector is improved. 3-2 Seminar for recruitment is held.

Source: Study Team

### 12.4.2 Candidate Project

Candidate projects for improvement of roads and bridges managed by the MPWT are found based on objectives analysis.

#### Candidate projects

Overall Goal	Program Purpose	Project Purpose	Project Outputs	(Main Activities)
Roads and Bridges in Cambodia are maintained properly.	Roads and Bridges managed by the MPWT are maintained properly.	Capacity on road and bridge maintenance of the MPWT is strengthened.	1. Organization for maintenance is strengthened.	1-1 A special organization for maintenance is established. 1-2 Roles, responsibilities and authority on maintenance are clarified. 1-3 Information and data are managed by one organization.
			2. Technology of maintenance is developed.	2-1 Maintenance guideline is developed. 2-2 Maintenance manual is developed. 2-3 Tools necessary for inspection are provided.
			3. Capability of engineers on maintenance is improved.	3-1 Items of the training for road structures engineers in the MPWT and DPWTs will be studied. 3-2 Training materials, planning of the training schedule and planning of the monitoring will be prepared. 3-3 Training to engineers in the MPWT and 24 DPWTs is implemented. 3-4 Qualification system for an inspector is developed.
			4. Maintenance management system is established.	4-1 Network is developed. 4-2 Data is managed by one organization. 4-3 Contents of data is adequate and enough. 4-4 System including evaluation of inspection result, study of alternatives, planning of repair and cost estimate is established.
		Sufficient budget for road and bridge maintenance is secured.	1. Funding source for road and bridge maintenance is found.	1-1 New funding sources for maintenance are found. 1-2 Tax rates of existing funding sources is revised. 1-3 Maintenance work is outsourced to the private sector. 1-4 Taxes collected from existing funding sources established for maintenance are all used for maintenance.
		Law/regulation on road traffic is complied.	1. Regulatory work and penalty against overloaded vehicles is strengthened.	1-1 Law/regulation on the road traffic is amended. 1-2 Amended law/regulation is applied strictly 1-3 Number of points for measuring weight of vehicles is increased. 1-4 Number of weight measurement machines is increased.
			2. Awareness activity to truck operators is carried out.	2-1 Explanation of traffic law/regulation is carried out. 2-2 Leaflets are produced and distributed.
		Number of engineers having enough knowledge and skill is increased.	1. Number of high-school students going to engineering universities is increased.	1-1 Image to engineering jobs is improved. 1-2 Scholarship system is established.
			2. Classes in Universities are enhanced.	2-1 Classroom hours are increased. 2-2 The most recent technology is taught. 2-3 Number of teachers is increased. 2-4 Teachers from developed countries are invited.
			3. Attractiveness of job in public sector is increased.	3-1 Salary of public sector is improved. 3-2 Seminar for recruitment is held.

Source: Study Team

### 12.4.3 Rough Schedule of Projects

The following projects and sub-projects are proposed based on analysis of problems and objectives to achieve the program purpose that “Roads and Bridges managed by the MPWT are maintained properly.”

**Table 12-29 Projects and Sub-project proposed for achieving the Program**

Project	Sub-project
Capacity on road and bridge maintenance of the MPWT is strengthened.	Organization for maintenance is strengthened.
	Technology of maintenance is developed.
	Capability of engineers on maintenance is improved.
	Maintenance management system is established.
Sufficient budget for road and bridge maintenance is secured.	Funding source for road and bridge maintenance is found.
Law/regulation on road traffic is complied.	Regulatory work and penalty against overloaded vehicles is strengthened.
	Awareness activity to truck operators is carried out
Number of engineers having enough knowledge and skill is increased.	Number of high-school students going to engineering universities is increased.
	Classes in Universities are enhanced.
	Attractiveness of jobs in public sector is increased.

Source: Study Team

Following is the basic idea of an implementation schedule of each project for achieving the program.

#### 12.4.3.1 “Capacity on road and bridge maintenance of the MPWT is strengthened.”

**(1) “Organization for maintenance is strengthened.”**

No organization for maintenance of roads and bridges exists in the MPWT. An organization for maintenance is the keystone not only for implementation of the project but also for continuous implementation of maintenance works. The organization and staffs for implementation of the project should be designated before starting the project. Roles, responsibilities and authority of the organization should be studied, decided and approved in the project.

**(2) “Technology of maintenance is developed.”**

A guideline, a manual and tools for maintenance are indispensable not only for training in the project but also for implementation of proper maintenance works. This sub-project should be implemented and completed in the project.

**(3) “Capability of engineers on maintenance is improved.”**

Capability improvement of engineers in the MPWT and 24 DPWTs is necessary for proper maintenance of all roads and bridges managed by the MPWT. However, training to all engineers responsible for maintenance within the project is difficult because of the limitations of duration, budget and number of experts inputted. Therefore, training to selected engineers of the MPWT and some the DPWTs should be implemented within the project. Engineers of remaining the DPWTs should be trained after the end of the project by the MPWT. Internal training to maintenance staffs should be planned and carried out continuously. This activity is very important to diffuse and secure maintenance technology within the organizations.

**(4) “Maintenance management system is established.”**

The maintenance management system consists of the bridge database and evaluation and planning method. The database is the essential core of the system. Establishment of the database and collecting necessary and correct data should be carried out in the project. Moreover, data collection through inspection should be continued for a long time after the end of the project for completing of the database. Development of evaluation and planning method should be implemented at the long-term stage for completion of the system. Enough data will be collected and the database will be completed by the end of middle- term stage.

**12.4.3.2 “Sufficient budget for road and bridge maintenance is secured.”**

Finding new sources, collecting taxes and appropriate allocation of budget for maintenance of roads and road structures should be implemented immediately for present and future maintenance works.

**12.4.3.3 “Laws/regulations on road traffic are complied.”**

Amendment of relevant laws and regulations on road traffic should be undertaken promptly and strict control of traffic violations should be implemented continuously. Various awareness activities to people concerned should also be carried out soon and continued.

**12.4.3.4 “Number of engineers having enough knowledge and skill is increased.”**

To increase the number of students taking examinations in engineering universities is important and the first step to develop many good engineers including civil engineers. Activities for increasing the number of students should be started soon and continued. Enhancement of classes in universities is important to increase the number of students and to develop good students. Activities necessary for enhancement of classes should be carried out immediately. The activity should be continued considering the needs of the time.

Increasing of attractiveness of jobs in the public sector including the MPWT is directly linked to obtaining many good engineers. Countermeasures for improvement of attractiveness should be carried out soon.

### 12.4.3.5 Rough Schedule of the Each Project

Table 12-30 shows the schedule of each project roughly.

**Table 12-30 Rough Schedule of Each Project**

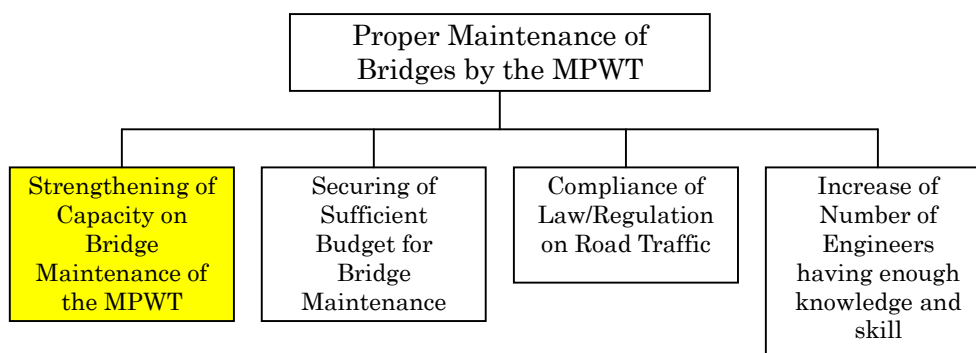
Program Purpose	Project Purpose	Project Activities	Agency Responsible	Before the Project	Short	Middle	Long
					3 years	5 years	5 years
Proper maintenance of bridges managed by the MPWT	Strengthening of capacity on bridge maintenance of the MPWT	Strengthening of organization for maintenance	MPWT & DPWT				
		Development of technology of maintenance					
		Improvement of capability of engineers on maintenance					
		Establishment of maintenance management system					
	Securing of sufficient budget for road and bridge maintenance	Finding of funding source for road and bridge maintenance	MEF				
	Compliance of law/regulation on road traffic	Strengthening of regulatory work and penalty against overloaded vehicles	Police and MPWT				
		Implementation of awareness activity to truck operators					
	Increase of number of engineers having enough knowledge and skill	Increase of number of high school students going to engineering universities	MEYS, MLVT, University and MPWT				
				Enhancement of class in universities			
				Increase of attractiveness of job in public sector			

Source: Study Team

### 12.4.4 The Project for Capacity Development of the MPWT and DPWTs

#### 12.4.4.1 Selection of the Capacity Development Projects

Four projects are proposed to achieve the program purpose.



Source: Study Team

**Figure 12-18 Program for Proper Maintenance of Roads and Bridges by the MPWT**

Expected implementing bodies of the projects are shown in Table 12-31.

**Table 12-31 Expected Implementing Bodies of the Projects**

Project	Expected Body
Strengthening of Capacity on Bridge Maintenance of the MPWT	MPWT and DPWT
Securing of Sufficient Budget for Bridge Maintenance	MEF
Compliance of Law/Regulation on Road Traffic	Police and MPWT
Increase of Number of Engineers having enough knowledge and skill	Universities, MPWT and MEF

Source: Study Team

The MPWT is the main target organization of the capacity development project. Therefore, the project in which “Capacity on road and bridge maintenance of the MPWT is enhanced” is the most appropriate for capacity development of the MPWT.

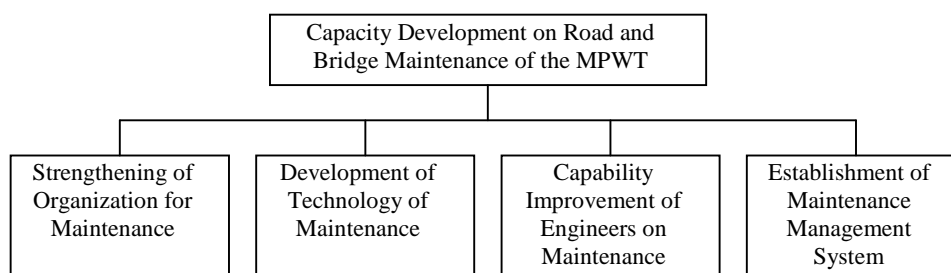
The remaining three projects are also very important to achieve the program purpose. The Cambodia should implement these projects at the same time.

A bridge is a part of roads. A road maintenance engineer’s point of view is necessary for bridge maintenance. Therefore, “Road” is put on the project title. However, the main target of the project is “Bridge” maintenance. The project should be carried out by cooperation of bridge maintenance engineers and road maintenance engineers.

#### 12.4.4.2 Basic Idea for Implementation of the selected Capacity Development Project

The selected project consists of four sub-projects.

- 1) “Strengthening of Organization for maintenance”
- 2) “Development of Technology of Maintenance”
- 3) “Capability Improvement of Engineers on Maintenance”, and
- 4) “Establishment of Maintenance Management System”



Source: Study Team

**Figure 12-19 Sub-projects of the Selected CD Project**

Following are the basic ideas for implementation of each sub-project of the selected capacity development project.

**(1) “Strengthening of Organization for maintenance”**

1) Study and Establishment of the Organization for Maintenance prior to implementation of the Project

A maintenance organization should be the actual implementation body of the next capacity development project. Strengthening of the organization and improvement of the maintenance technology of engineers in the organization should be carried out through the project. This organization should also be responsible for continuous maintenance after the project. Unfortunately, however, no independent or special department or section for maintenance exists in the MPWT or DPWTs. Therefore, the study on the new organization should be implemented and the new organization/section should be formulated prior to implementation of the project.

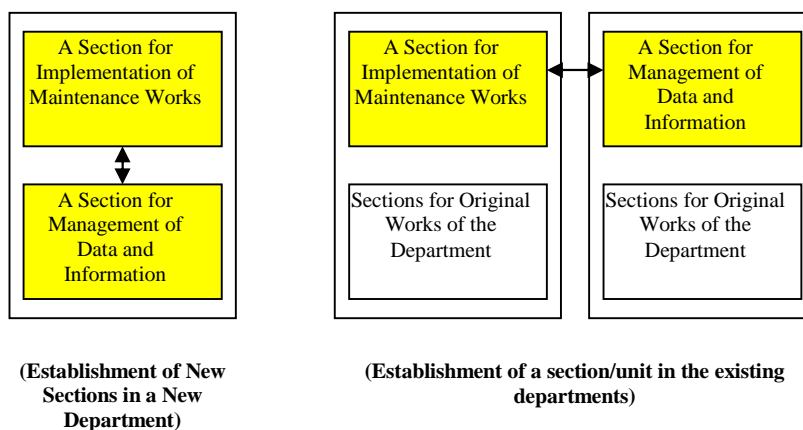
Following are expected to be studied for establishment of the new organization/section.

- Staffs necessary for the organization
- Roles, responsibilities and authority of the organization
- Unification of information and data, and
- Outsourcing of maintenance works

2) Type of Organization

Two types of the new organization are expected.

One is to establish a new organization (a department) responsible for implementation of maintenance works and management of data and information related to maintenance works. The other is to establish a section or unit for implementation of maintenance works and management of data and information in an existing organization (a department). The JICA Study Team recommends the latter. However, the type of the new organization should be studied and established considering ease of establishment and getting budget, necessity of amendment of laws related to the organization, smoothness of operation of the organization, etc.



Source: Study Team

**Figure 12-20 Type of Organization for Maintenance of Bridges**



3) Activities expected in the Project

The new organization should be a project management unit (PMU) or a core of the project and also be responsible for maintenance works after the project. Even if the new organization is not established prior to implementation of the project, the responsible organization should be designated and necessary permanent staffs for implementation of the project should be allocated. Following should be carried out in the project.

- a) Discussion and decision of roles, responsibilities and authority of the organization responsible for road structures maintenance
- b) Study and decision of the maintenance organization in the DPWT, and
- c) Approval of roles, responsibilities and authority by the MPWT

(2) **“Development of Technology of Maintenance”**

1) Development of a Comprehensive Guideline and a Manual for Maintenance

Both permanent and temporary bridges exist in Cambodia at present. A comprehensive guideline and a manual for maintenance of bridges are necessary for standardization and equalization of maintenance works. No guideline or manual has been developed in Cambodia yet. Therefore, the guideline and the manual should be developed at an early stage in the project. Following contents should be studied, discussed and included in the guideline and the manual developed in the project.

Table 12-32 shows expected main contents of a guideline and a manual.

**Table 12-32 Main Contents of a Guideline and a Manual**

<b>Guideline</b>	<b>Manual</b>
<ul style="list-style-type: none"> <li>• Policy and Purpose of bridge maintenance</li> <li>• Flow of bridge maintenance</li> <li>• General theory of bridge maintenance</li> <li>• Scope of application of the Guideline</li> <li>• Definition of terms used in the Guideline</li> <li>• Explanation of each item necessary for bridge maintenance</li> <li>• Sample of bridge maintenance</li> </ul>	<ul style="list-style-type: none"> <li>• Bridge Maintenance Activities and Flow of Information</li> <li>• Main Parts of a Bridge</li> <li>• Basic Technical Terms of Bridges</li> <li>• Responsibility and Duty of the Bridge Inspector</li> <li>• Inventory Survey and Periodical Inspection for Bridges</li> <li>• Bridge Report System</li> <li>• Coding Guide for Bridge Inventory Data</li> <li>• Coding Guide for Condition Rating for Bridge Elements</li> </ul>

Source: Study Team

2) A Manual for Large Scale Bridge Inspection

Nine (9) large-scale bridges across the Mekong and other big rivers have been constructed recently. Large-scale bridges are classified into three types. Inspection points and inspection precautions are different depending on the size and type of bridge. Therefore, a manual for large-scale bridges should also be provided by type after development of the comprehensive manual in the project.

**Table 12-33 Type of Large Scale Bridges in Cambodia**

Type of Large Scale Bridge	No. of Bridges
Pre-stressed Concrete Cable-stayed Bridge	1
Pre-stressed Concrete Box-Girder Bridge	6
Steel Box-Girder Bridge	2
Total	9

Source: Study Team

3) Development of an Inspection Sheet and Judgment Criteria

A bridge inspection sheet and unified criteria for damage judgment are very useful and indispensable for obtaining unified bridge data and for proper maintenance. Development of the sheet and the criteria should be carried out at the same time as the development of the manual in the project. The sheet and the criteria developed in the project should be used at the pilot project and modified and completed.

Inspection points of bridges are largely divided into two areas. One is the material of the bridges and the other is the components of the bridges. In Cambodia, concrete, steel including Bailey, wooden and stone bridges exist. Inspection items are determined based on the material type of the bridges. Bridge components are largely divided into three (3) groups – super structure, sub-structure and others. The main body of a bridge consists of the super structure and sub-structure. The super structure consists of the main parts and accessories. The main parts and accessories also consist of many parts. Sub-structure is a generic term used to refer to abutments and piers with or without piles. Others are “Riverbed” condition of sub-structure, “Protection” condition of abutment, pier and river bank and “Right of Way” of a bridge or a road. Table 12-34 shows typical inspection items in an inspection sheet. Bridge material, components and items of inspection in an inspection sheet should be studied, discussed and decided considering bridge condition in Cambodia.

**Table 12-34 Typical Inspection Items in an Inspection Sheet**

Bridge Material and Component of Inspection			Items of Inspection	
<b>Bridge Material</b>				
Concrete			Cracks, Fissures, Exposure, Deformation, Water seepage, etc.	
Steel			Rusting, Painting, Corrosion, Deformation, Missing bolts, etc.	
wood			Cracks, Corrosion, Deformation, etc.	
Stone			Opening of joints, Deformation, etc.	
<b>Component</b>				
Main parts of a bridge	Super Structure	Main elements	Slab, Beam or Girder, etc.	Cracks, Fissures, Exposure, Cavities, Holes, etc.
		Accessories	Pavement, Hand rail, Expansion, Drainage, Bearing, etc.	Waving, Bumps, Rut, Cracks, Holes, Deformation, Rust, Missing parts, Exposure, Water seepage, Obstruction, etc.
	Sub structure	Abutment	Breast wall, Back wall, Wing wall, etc.	Cracks, Fissures, Exposure, Cavities, etc.
		Pier	Cap beam, Column, Pile cap	
Foundation		Footing, Pile, Pile bent, etc.		
Periphery of a bridge	Riverbed			Bed condition, Gradient, Erosion, etc
	Protection	Abutment		Erosion, Opening of joints, Deformation, Grass developing, etc.
		Pier		
		Embankment		
R.O.W.	Occupation		Building, Inhabitant, etc.	

Source: Study Team

4) Preparation of Inspection Tools

In order to carry out an accurate and comprehensive inspection, the proper tools should be provided and used at the pilot project. Standard tools that an inspector should prepare for the bridge inspection can be grouped into six basic categories. Expected tools are shown in Table 12-35. The Inspector can use the table as a checklist to prepare the tools for the inspection.

**Table 12-35 Checklist of Standard Bridge Inspection Tools**

Objective	Tool	Check
Cleaning	<b>Wisk broom</b> to remove loose dirt and debris <b>Wire brush</b> to remove paint and corrosion from steel <b>Scrapers</b> to remove the corrosion from the elements in the surface <b>Flat bladed screwdriver</b> for general cleaning and probing <b>Shovel</b> to remove dirt and debris.	
Inspection	<b>Pocket knife</b> for general duty <b>Ice Pick</b> for surface examination of timber elements <b>Hand brace and bits</b> to investigate the timber elements <b>Increment borer</b> for the internal examination of timber elements <b>Chipping hammer</b> for the examination of the concrete surface <b>Plum bob</b> to measure the vertical alignment <b>Tool belt</b> with tool pouch to hold small tools	
Visual aid	<b>Binoculars</b> to examine at distances <b>Flash light</b> to examine in dark areas <b>Lighted magnifying glass</b> to closely examine the cracks <b>Inspection mirrors</b> for the inspection of inaccessible areas	
Measuring	<b>Pocket tape and 50m tape</b> to measure the dimensions. <b>Calipers</b> to measure the thickness of elements <b>Optical check gage</b> for the precise measurement of the width of the crack. <b>Tiltmeter and protractor</b> to determine the tilting of element. <b>Thermometer</b> to measure the temperature <b>Carpenter's level</b> to measure the slopes and settlements	
Documentation	<b>Inspection form, clipboard and pencil</b> <b>Field book</b> <b>Straight edge</b> to draw <b>Digital camera</b> for visual documentation <b>Chalk or markers</b> for element identification and photo <b>Portable GPS</b> to measure the coordinates of the bridge	
Miscellaneous	<b>Safety hook and belt</b> for a safe inspection when working at heights <b>C-clump</b> use to provide a third hand when measuring. <b>Insect repellent and wasp and hornet killer</b> <b>First aid kit</b> for small cuts and bee stings <b>Toilet paper and Towels</b> for emergencies and cleaning	

Source: Study Team

5) Activities expected in the Project

Following are activities expected for achieving a sub-project for development of maintenance technology.

- a) Development of a guideline and a manual for bridge maintenance
- b) Development of a manual and a guideline for large scale bridge maintenance, and
- c) Provision of necessary tools for bridge inspection

**(3) “Capability Improvement of Engineers on Maintenance”**

1) Stage and Target of Training

Engineers involved in maintenance works of road structures in the MPWT and 24 DPWTs have inadequate knowledge and skill on maintenance works. Training for them is indispensable for continual proper maintenance of bridges. Training will be carried out in a room and at sites using training material developed based on the guideline, the manual and the inspection sheet.

Training for all engineers involved in maintenance works of bridges in the MPWT and 24 DPWTs during the project period is difficult because of the limitations of duration, budget and number of experts inputted. Therefore, capability development of engineers in the MPWT and 24 DPWTs should be implemented in two different stages as follows. Engineers of the maintenance organization in the MPWT should be trained first. Training to engineers in some selected the DPWTs should be carried out by the trained engineers of the maintenance organization in the MPWT at a pilot project within the project. Training to engineers in remaining the DPWTs should be implemented by engineers trained in the project after the project is completed. Training should be carried out continuously.

**Training Stage**

At the Project:  
After the Project:

**Target of Training**

Engineers in the MPWT and some selected DPWTs  
Engineers in remaining DPWTs

2) Overseas Training

Training on maintenance of bridges in a developed country is very useful for engineers in the MPWT and DPWTs. Training in Japan should be considered in the project.

Contents of training in Japan should consist of classroom lectures and visiting maintenance worksites.

3) Establishment of Qualification System for the Inspectors

The qualification system for inspectors should be established in the project to upgrade inspection skills. Following will be taken into consideration for establishing the qualification system.

- a) An authorized organization for implementation and issuance of the qualification
- b) Persons responsible for the qualification test
- c) Authorization of the test
- d) Timing, place and, frequency of the test
- e) Issuance of the certificate, and
- f) Rights and responsibilities of an inspector

4) Activities expected in the Project

Following are activities expected for achieving a sub-project for capability improvement of engineers on maintenance.

- a) Development of training material, planning of the training schedule and the monitoring
- b) Selection and training of trainees (engineers) of the MPWT and DPWTs
- c) Implementation and monitoring of the pilot project
- d) Overseas training
- e) Establishment of qualification system, and
- f) Exchange of information with developed countries

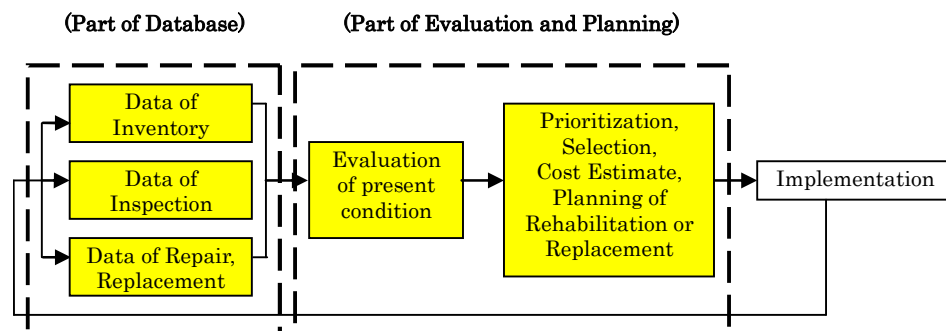
**(4) “Establishment of Maintenance Management System”**

1) Priority Development of the Bridge Database

Bridge maintenance including up-grading of bridge function is implemented for reducing lifecycle cost of bridges. Maintenance works including inspection, repair, and strengthening of temporary bridges should be implemented until the bridge is replaced to permanent bridge.

The BMS is roughly classified into two parts. One is the database and the other is the evaluation and planning method. The database consists of bridge inventory data including design and construction documents for the bridges, inspection data and data of repair, reinforcement and replacement. Evaluation and planning consists of evaluation of present bridge condition, prioritization, selection of counter measures, cost estimate, deterioration prediction and planning of repair and/or replacement.

Concept and main contents of the BMS are shown in Figure 12-21 and Table 12-36.



Source: Study Team

**Figure 12-21 Concept of BMS**

**Table 12-36 Main Contents of BMS**

BMS	Database	• Data of inventory including design and construction documents
		• Data of inspection
		• Data of repair, reinforcement and replacement
	Evaluation & Planning	• Evaluation of present bridge condition
		• Prioritization, Selection of Counter Measure, Cost estimate, Deterioration prediction, Repair/Replacement plan

Source: Study Team

However, no database has been developed yet. Sufficient and correct data and information on bridges are not collected. Inspection data has not been recorded and stored. Documents related to maintenance have not been managed adequately. Documents on construction of roads, bridges and other road structures are now being collected by the quality control project. The database is a keystone of the system. Therefore, the database especially bridge inventory data should be collected and compiled at first in the project. Evaluation and planning methods will be studied in the project for completion of the BMS in the future.

2) Development of the Bridge Inventory

The database consists of three sets of data as mentioned above. Of these, the bridge inventory is the ledger to manage basic data and information on a bridge necessary for bridge maintenance in the future. Data and information of 61 items will be needed for the inventory. Table 12-37 shows expected bridge inventory items.

**Table 12-37 Expected Bridge Inventory Items**

Items				
General Data	Bridge Identification Data	Bridge Name, Bridge ID, Road ID, Coordinate, Province, etc.		
	Bridge Condition Data	Load Limit, Width Limit		
	Location Condition Data	Feature being crossed	Crossing Type, Name, Width, Depth, H.W.L.	
		Geological Condition	Bed Condition, Surface Condition, Depth of Support Layer	
		Utilities	Water, Electricity, Telephone, etc.	
Bridge Basic Information	Construction and Repair Year, Bridge Type, Material, Bridge Length, No. of Spans, etc.			
Specific Data	Bridge Surface	Pavement	Material, Thickness	
		Guard Rail	Material	
	Super Structure	Slab	Material, Thickness	
		Girder	Material, Height, Length, Number	
	Sub-structure	Abutment	Structure, Dimension, Foundation	
		Pier	Structure, Beam, Column, Foundation	
	Accessory	Bearing	Type, Size, Number	
		Expansion	Type, No. of Movement	
	Protection	Around Abutment	Type	
	Others	Document	Detail or As-build Drawings, Reports, Photos, etc.	
Right of Way (R.O.W.)	Illegal Occupation and Use of Land	Type, Use and No. of Buildings, Land Use, etc		

Some projects to develop data for road and bridge maintenance are implemented by the WB and other donor agencies and JICA. The RAMP is being carried out by the HEC by support from WB and others to collect general data on road assets such as roads including pavement, bridges, culverts and drainages. JICA is also conducting the Study. General and detailed data on bridges are being collected from selected bridges for studying prioritization of bridge replacement. Data obtained from these projects will be useful for future maintenance of roads and bridges. Therefore, these data should be utilized for the project as much as possible.

However, data collected at two projects is not sufficient for the inventory from type of data and number of bridges and items point of view. Therefore, the inventory should be developed in the project at first.

**Table 12-38 Comparison of Data Collected**

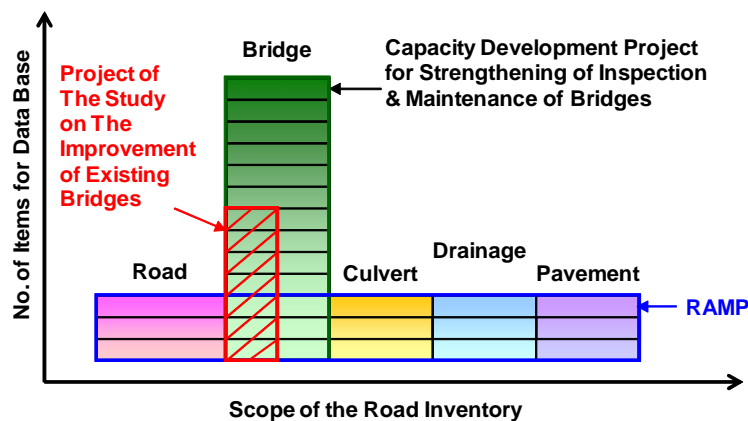
Project Name	Target	Type of Data	Number	
			Bridges	Items
CD Project for Inspection and Maintenance of Bridges* <sup>1</sup>	All bridges managed by the MPWT	General and detailed data & information	More than 2,000	67* <sup>3</sup>
The Improvement of Existing Bridges (JICA)* <sup>2</sup>	Bridges selected for the study	General and detailed data & information	About 1,200	37
RAMP (WB & others)* <sup>2</sup>	All road assets (roads, pavement, bridges, culverts, drainage)	General data & information	More than 2,000	20

Source: Study Team

Note:\*1 The project which will be implemented near future,

\*2 The project being implemented at present.

\*3 Expected number of a permanent bridge inventory items collected.



Source: Study Team

**Figure 12-22 Image of Data Collection on Road Assets by Project**

An inventory survey should be conducted in the project for collection of bridge inventory data. About 2,200 bridges managed by the MPWT exist. Of these, 1,205 bridges were



surveyed and data of 37 items per bridge were collected by the Study Team. However, data of a total 65 items per bridge are needed. Inventory survey for 1,205 bridges will be needed in the project for collecting the remaining 28 items per bridge. Moreover, about 1,000 bridges were not surveyed. The RAMP is supposed to collect general information on 20 items. Therefore, the inventory survey for 1,000 bridges should also be conducted to collect data of the 45 items per bridge in the project. However, progress situation of and accuracy of data collected by the RAMP must be paid attention. In some cases, the data collected will not be used. In that case, data of 65 items per bridge has to be collected from 1,000 bridges. Table 12-40 shows comparison of bridge inventory items of the three projects.

**Table 12-39 No. of Bridges and Items necessary for Inventory Survey**

Target Bridge	No. of Bridges & Items surveyed		Remarks
	Bridges	Items per Bridge	
Additional survey for bridges surveyed by the JICA project	1,205	28	=65-37
Survey for other bridges	1,000	45	=65-20
Total	2,205		

Source: Study Team

Table 12-40 Comparison of Bridge Inventory Items

Items		Collecting items					
		permanent bridge	The Improvement of Existing Bridges	RAMP			
General Data	Bridge Identification Data	Bridge Name	○	○	○		
		Bridge ID	●		○		
		Road ID	●	○	○		
		Station(Running Chainage)	○		○		
		Coordinate	●	○	○		
		Province	●	○	○		
	Bridge Capacity Data	Vehicle	Actual	○	○	○	
			Design	○			
		Width (m)	Approach Roadway Width	○	○	○	
			Bridge Roadway Width	○			
	Traffic	Actual	○				
	Condition of Location	Feature being crossed	Crossing type	●	○	○	
			Name	○	○	-	
			Width	○	○	-	
			Depth	○	○	-	
		Geological Condition	Feature	○	○	-	
			State of the Surface	○	-	-	
			Depth of the support layer	○	-	-	
	Utilities	○	○	○			
	Basic Condition	Construction Year	○	○	○		
		Immediate Repair Work Year	○		○		
		Type of structure	●	○	○		
		Material	●	○	-		
		Bridge Length	●	○	-		
		Span/Cell	●	○	○		
		Clear height	○	○	○		
		Dimension of transverse section	●	○	-		
		Total Width	●	○	○		
		Specification	○	-	-		
	Specific Data	Surface	Pavement	Material	●	○	-
				Thickness	○		-
			Guard Rail	Material	○		-
Super Structure		Slab	Material	●	○	-	
			Thickness	○		-	
		Girder (Each Span)	Material	●	○	-	
			Height of girder	●	○	-	
			Length of span	●	○	-	
Number of girder		●	-	-			
Sub-Structure		Abutment	Type of structure	●	○	○	
			Outline Dimension	Type	○	○	-
				Dimension	○	-	-
		Pier	Type of structure	●	○	-	
			Beam	Material	○	-	-
				Type	○	-	-
				Dimension	○	-	-
			Colum	Material	○	-	-
				Type	○	-	-
				Dimension	○	-	-
Foundation		Type		●	○	-	
Dimension		○	-	-			
Accessory		Bearing	Type	●	-	-	
			Size	○	-	-	
			Number	○	-	-	
		Expansion	Type	●	-	-	
Amount of movement		○	-	-			
Protection		Abutment	○	○	○		
		Pier	○	○	○		
		Bank	○	○	○		
Others		As-Build-Drawings	○	-	-		
		Documents	○	-	-		
		Photos	○	○	-		
Right of way		Illegal occupation	○	○	-		
	Use of Land	○	○	-			
Total of Items			65	37	20		

● : Necessary Items      ○ : Possible Items

Source: Study Team

Traffic count surveys should also be conducted in the project to obtain traffic volume. The MPWT manages a total of 330 roads including 8 one-digit roads. Of these, 158 roads of 2-, 3- and some 4-digit roads were selected for traffic count surveys. Traffic count was carried out at 193 points by the Study Team. Traffic count on the 172 remaining roads including 8 one-digit roads is also needed for betting data on traffic volume. Therefore, traffic count surveys at around 200 points on 172 roads should be conducted. These surveys should be outsourced to local survey companies by management of the project team.

3) Development of Inspection Data

Inspection data on bridges in some provinces will be collected and inputted to the inventory at the pilot project implemented within the project. The data on bridges in the remaining provinces should be collected and inputted to the inventory by the MPWT and DPWTs after finishing the project. This work should be continued not only for completion of the bridge inventory but also for updating of data.

4) Development of Repair, Reinforcement and/or Replacement Data

Data on repair, reinforcement and/or replacement of road structures is a part of the database and important for maintenance. Therefore, the data should be recorded and managed properly when repair, reinforcement and/or replacement of road structures are implemented. Expected data items for repair are shown in Table 12-41

**Table 12-41 Expected Data Items for Repair**

No.	Item
1	Bridge No. (Code No.)
2	Road Name
3	Repair No. (Code No.)
4	Repair Period (Date of Start and Finish)
5	Type and/or Name of Repair
6	Repair Place
7	Size or Scale of Repair
8	Repair Cost
9	Repair Method
10	Repair Company

Source: Study Team

5) Planning of Components and Preparation of Equipment necessary for the Database system

Proper components for the Database system should be studied and planed considering the network environment in Cambodia in the project. Equipment necessary for the system should also be studied considering the existing equipment in the MPWT and DPWTs. Equipment including a client-server and software for the database management necessary to operate the system should be prepared prior to the pilot project.

6) Activities expected in the Project

Following are activities expected for achieving a sub-project for establishment of database.

- a) Confirmation of existing information and data on bridges
- b) Examination of network environment and proper components
- c) Preparation of equipment
- d) Development of the database
- e) Study of method for evaluation, prioritization, and cost estimation of repair for establishment of the bridge management system in the future
- g) Development of database manual, and
- h) Seminar

**12.4.4.3 Rough Implementation Schedule of the CD Project**

Based on the basic ideas for implementation of each sub-project, a rough implementation schedule for the capacity development project is shown in Table 12-42.

**Table 12-42 Rough Implementation Schedule for the Sub-Project**

Sub-Project	Activities	Prior to the Project	Short	Middle	Long
			3 years	5 years	5 years
Strengthening of organization for maintenance	Designation of the organization, Allocation of staffs				
	Decision and approval of role, responsibility and right of organization				
Development of technology of maintenance	Development of the regulation and the manual, etc.				
Improvement of capability of engineers on maintenance	Training to the engineers in the MPWT and selected DPWTs				
	Training to the engineers in other DPWTs (continuous training)				
Establishment of Maintenance Management System	Data collection and compilation (continuous work)				
	Development of the remaining part of BMS				

Source: Study Team

**12.4.4.4 Draft Detail Contents of the CD Project**

Following are draft detail contents of the capacity development.

**(1) Strengthening of the Organization responsible for maintenance**

- 1) Discussion and decision of roles, responsibilities and authority of the organization responsible for road structures maintenance
- 2) Study and decision of the maintenance organization in the DPWT, and
- 3) Approval of roles, responsibilities and authority by the MPWT

**(2) Development of technology for maintenance**

- 1) Development of a guideline and a manual for bridge maintenance
- 2) Development of a manual and a guideline for large scale bridge maintenance, and
- 3) Provision of necessary tools for bridge inspection

**(3) Improvement of capability of engineers in the MPWT and DPWTs for maintenance**

- 1) Study and decision of items for the training for road structures engineers in the MPWT and DPWTs
- 2) Development of training materials, planning of the training schedule and planning of the monitoring
- 3) Selection and training of engineers from the MPWT.
- 4) Examination of contents of the training
- 5) Training of engineers of the provinces as inspectors for the pilot project of road structure maintenance.
- 6) Implementation of the pilot project in some provinces and monitoring.
- 7) Training of inspectors in Japan.
- 8) Establishment of qualification system for the inspector
- 9) Exchange of information with developed countries on road and bridge maintenance

**(4) Development of the bridge database**

- 1) Examination of existing information and data of bridges
- 2) Examination of the network environment and proper components of the bridge database in Cambodia
- 3) Preparation of equipment necessary for the bridge database
- 4) Decision of data components necessary for the bridge database
- 5) Design and programming of the bridge database
- 6) Development of the database based on existing information and data of road structures
- 7) Collection of additional data by site survey (bridge inventory and traffic count) and completion of the database
- 8) Study of items of inventory data and method for evaluation, prioritization, and cost estimation of repair for establishment of the BMS in the future
- 9) Development of database manual
- 10) Seminar for development (updating) of bridge database

**12.4.4.5 Detailed Implementation Schedule, Manning Schedule of the Program**

**(1) Detailed Implementation Schedule of the Project**

The Project will be implemented for three (3) years. Expected detailed project and manning schedule are shown in Figure 12-23 and Figure 12-24 respectively.

**(2) Expected Team Members of the Project**

Expected team members of the project are shown in Table 12-43.

**Table 12-43 Team Member**

Experts	Counterparts
<ul style="list-style-type: none"> <li>• A chief advisor</li> <li>• A bridge maintenance engineer</li> <li>• A road maintenance engineer</li> <li>• An organization analyst</li> <li>• A bridge database engineer</li> <li>• Two Bridge inspectors (Trainers)</li> </ul>	<ul style="list-style-type: none"> <li>• A director</li> <li>• A deputy director</li> <li>• Two Bridge engineers from MPWT</li> <li>• Two road engineers from MPWT</li> <li>• Four engineers as inspectors from the MPWT</li> <li>• Eight engineers as inspectors from DPWTs</li> <li>• Two IT specialists from MPWT</li> </ul>
Total: 7 members	Total: 20 members

Source: Study Team

**(3) Input**

1) Expected Man-Months

Expected Man-Months of Experts and Counterparts are shown in Table 12-44.

**Table 12-44 Man-Month of the Project**

Experts		Counterparts	
Member	M/M	Member	M/M
A chief advisor	36	A director	2
A bridge maintenance engineer	21	A deputy director	4
A road maintenance engineer	13	A bridge engineer (1)	18
An organization analyst	4	A bridge engineer (2)	18
A bridge database engineer	9	A road engineer (1)	12
A Bridge inspector (1)	6	A road engineer (2)	12
A Bridge inspector (1)	6	An inspector from the MPWT (1)	11
		An inspector from the MPWT (2)	11
		An inspector from the MPWT (3)	11
		An inspector from the MPWT (4)	11
		Eight inspectors from DPWTs	56
		Two IT specialists (1)	22
<b>Total</b>	<b>95</b>	<b>Total</b>	<b>188</b>

Source: Study Team

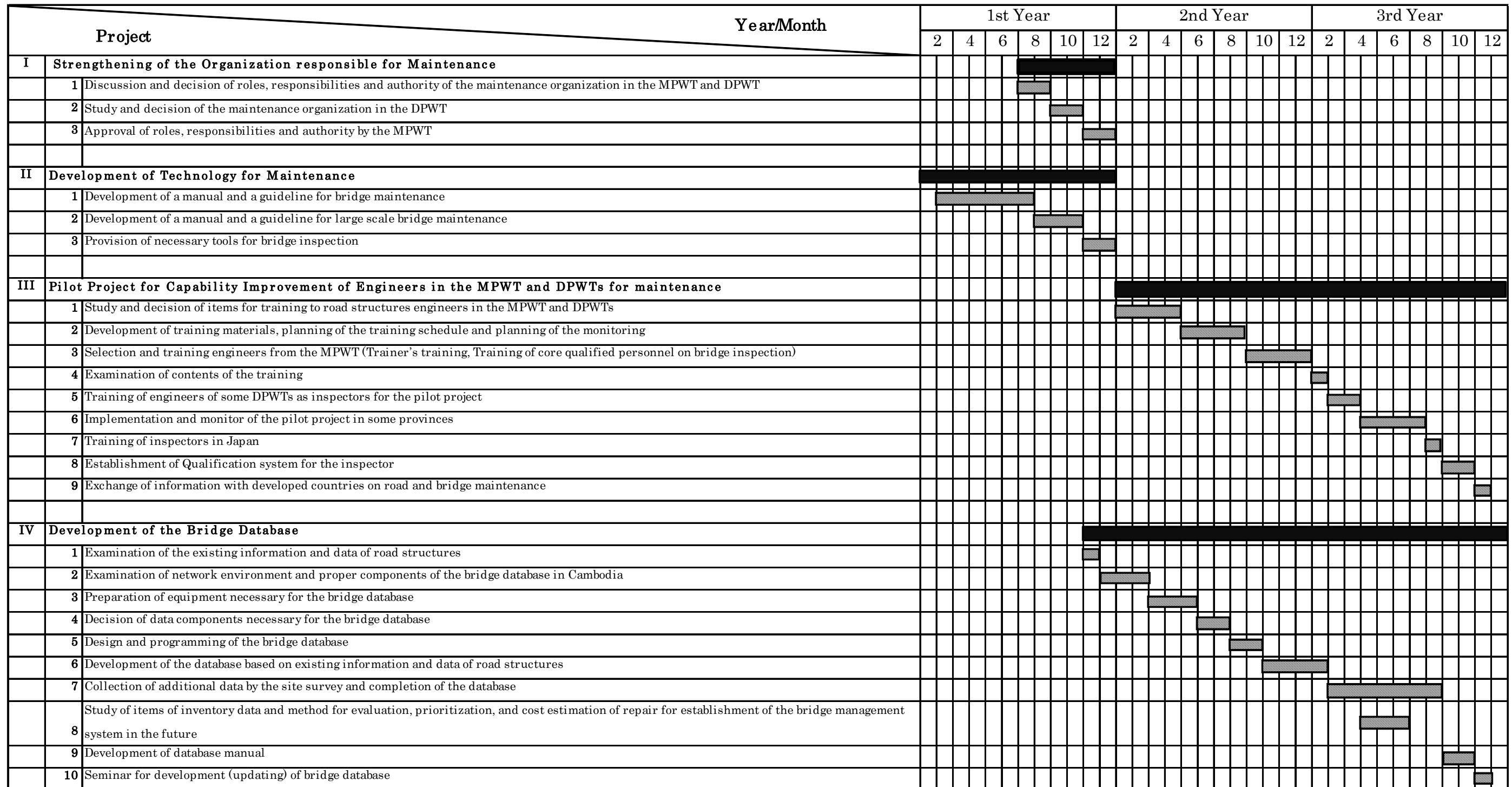
2) Others

Table 12-45 shows other expected input from both sides.

**Table 12-45 Other Input from both side**

Japan	Cambodia
<ul style="list-style-type: none"> <li>• Inspection tools</li> <li>• Database equipment</li> <li>• Document development cost</li> <li>• Seminar expenses</li> <li>• Training cost of counterparts in Japan</li> <li>• Bridge Inventory survey cost</li> <li>• Traffic count survey cost</li> </ul>	<ul style="list-style-type: none"> <li>• Office space at MPWT &amp; DPWTs</li> <li>• Office equipment at MPWT &amp; DPWTs</li> <li>• Domestic travel cost of counterpart</li> </ul>

Source: Study Team



Source: Study Team

Figure 12-23 Project Schedule

Project	Year/Month	1st Year						2nd Year						3rd Year						
		2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	
I	Strengthening of the Organization responsible for Maintenance																			
II	Development of Technology for Maintenance																			
III	Pilot Project for Capability Improvement of Engineers in the MPWT and DPWTs for maintenance																			
IV	Development of the Bridge Database																			
<b>Experts Team</b>																				
	1 A Chief Advisor	36																		
	1 A Bridge Maintenance Engineer	21																		
	1 A Road Maintenance Engineer	13																		
	1 An Organization Analyst	4																		
	1 A Bridge Database Engineer	9																		
	1 An Inspector - Trainer (1)	6																		
	1 An Inspector - Trainer (2)	6																		
	7 total	95																		
<b>Counterpart Team</b>																				
	1 A Director	2																		
	1 A Deputy Director	4																		
	1 A Bridge Engineer (1)	18																		
	1 A Bridge Engineer (2)	18																		
	1 A Road Engineer (1)	12																		
	1 A Road Engineer (2)	12																		
	1 An Inspector (MPWT 1)	11																		
	1 An Inspector (MPWT 2)	11																		
	1 An Inspector (MPWT 3)	11																		
	1 An Inspector (MPWT 4)	11																		
	8 Eight Inspectors (DPWTs)	56																		
	1 An IT Specialist (1)	11																		
	1 An IT Specialist (2)	11																		
	20 total	188																		

Source: Study Team

Figure 12-24 Manning Schedule