ECONOMIC ANALYSIS

1. An economic analysis of output 1 (more safe and climate resilient national roads delivered) was performed. Under this output, the project will provide periodic maintenance and rehabilitation with asphalt concrete on 146.6 kilometers (km) of national road. National Road (NR)1 and NR6 are major arterial roads that are part of the Greater Mekong Subregion (GMS) Southern Economic Corridors (SECs) 1 and 2.[1] Output 2, 3, and 4 concern sector-wide improvements of axle load control, quality assurance, and road safety enforcement. No economic analysis was performed for these institutional strengthening components as their benefits are indirect and less clearly attributable to the project.

A. Macroeconomic and Sector Context

2. Cambodia's economy has been consistently growing at a rate of 7% or more annually since 2011, after it recovered from the global financial crisis of 2008–2009. Cambodia currently has four drivers of growth: agriculture, tourism, manufacturing (mainly garments for export), and commercial and residential construction. Each of these drivers is dependent on the efficiency of road transport, which is the main transport mode in Cambodia. Demand for road transport is increasing at a fast pace in Cambodia, as it is in other fast-growing Southeast Asian countries. The number of vehicles in the country increased from 330,000 in 2000, to 1.1 million in 2008 and reached 3.2 million in 2015. Motorcycles account for close to 85% of the vehicle fleet. Primary roads have been paved, which has decreased logistics costs on the main links. Adequate road maintenance and preservation from damage from overloaded vehicles is important to sustaining Cambodia's growth.

B. Project Definition and Option Analysis

3. Maintenance and rehabilitation works will extend road pavement life by 10 years, improving riding condition and providing consistent pavement condition on the targeted sections. Pavement maintenance needs were determined during the project preparatory technical assistance based on an analysis of the current pavement strength and condition, and requirements to meet future traffic load. The road improvement program is described in Table 1.

Table 1: Road Improvement Program Description

Road No.	Length (km)	Carriage-way width (m)	Pavement Type	Pavement Condition	Planned Works	Financial Costs ($ million)	Financial Cost/Km ($)
NR1	96.9	10.0–10.6	DBST	Fair with potholes and cracks sealed	AC 50 mm overlay (97%) Full-depth rehabilitation with AC (3%)	31.7	325,000
NR6	49.7	10.6	DBST (16 km) AC (34 km)	Good (16 km), fair to poor (34 km)	AC 50 mm overlay (51%) Full-depth rehabilitation with AC (49%)	22.4	450,000

AC = asphalt concrete, DBST = double bituminous surface treatment, m = meter, mm = millimeter, NR = national road

Note: In this table, civil works financial costs include civil works, consulting, and administration but do not include price contingencies, interests during construction, and maintenance costs.

Source: Asian Development Bank estimates.

[1] SEC 1: Dawei–Bangkok–Phnom Penh–Ho Chi Minh City–Vung Tau; SEC 2: Bangkok–Siam Reap–Stung Treng–Pleiku–Quy Nhon.

C. Traffic Forecasts

4. **Traffic baselines.** Traffic baselines for NR1 and NR6 were calculated based on (i) 6 years (2010–2015) of annual records of counting stations, and (ii) 3-day classified traffic counts carried out in October 2016. The number of vehicles on both NR1 and NR6 is more than 10,000 per day. The share of light traffic (motorcycles and bicycles) is 60%–65% on the national roads.

5. **Traffic growth.** On NR1 and NR6, motorcycles and cars have experienced a growth rate of approximately 7% per annum since 2010. The growth rate for trucks was above 10% while for buses it was between 5% and 10% depending on the sections. Traffic growth rates for all sections were determined based on an analysis of time series of vehicle registrations and historical traffic volumes, and by applying elasticities of vehicle registrations with respect to gross domestic product (GDP) to forecasts of future GDP growth rates (Table 2). Road maintenance works on NR1 and NR6 are not expected to raise the demand for trips.

Table 2: Assumed Traffic Growth Rates

(%)

Vehicle Group	2016–2020	2021–2025	2026–2030	2031–2035
Motorcycles	7.7	5.9	4.6	3.8
Cars	6.5	5.3	4.4	3.9
Buses	6.5	5.1	4.2	3.8
Goods vehicles	8.3	6.4	4.9	4.2

6. Traffic forecasts in the project case are presented in Table 3.

Table 3: Traffic Forecasts in the Project Case

(average annual daily traffic)

	Baseline (2016)					Forecasts (Total)	
Highway	Motorcycles	Cars	Bus	Trucks	Total (w/o motorcycles)	2025	2030
NR1	9,614	1,902	1,239	1,753	4,894	8,300	10,360
NR6	7,925	3,411	688	1,158	5,257	8,920	11,140

NR = national road, w/o = without.
Source: Asian Development Bank estimates.

D. Economic Costs and Benefits

7. The evaluation period is 10 years for NR1 and NR6 as the roads will only receive periodic maintenance treatments.

8. **Project costs.** The economic costs of the road works financed under the project are $52.9 million. For the purpose of modeling, periodic maintenance works are considered to be implemented over a period of 2 years (2018–2019), while reconstruction works are considered to be implemented over 3 years (2018–2020). Project capital costs include the costs of the works, design, supervision, management, resettlement, land opportunity costs, and environmental mitigation. The economic analysis was conducted using the United States dollar as the unit of currency, and the domestic price numeraire, with mid-2016 base year estimates. Financial costs were converted into economic costs by (i) excluding financial charges, taxes, and price contingencies; (ii) using a shadow conversion factor of 1.02, calculated based on Cambodia's import and export trade data and related taxes and applied to the tradable part of costs; and (iii) using a shadow wage rate factor of 0.70 for unskilled labor.

9. **Highway maintenance.** Road degradation was modeled using Highway Development and Management (HDM4) software, following standard ADB practice for this type of investment. Paved road maintenance assumptions include routine maintenance; pothole patching, repair of edge breaks, and sealing of cracks; and single surface treatment applied when cracking appears but remains moderate. Gravel road maintenance assumptions included regraveling every 3 years and biannual grading. For all roads, the new asphalt concrete and double surface treatment surfaces will require less repairs than older pavements.

10. **Reduction in vehicle operating and travel time costs**. The improvement of the pavements will reduce vehicle operating costs (VOCs) and shorten travel time and therefore travel time costs, in comparison with the base-case scenario. Periodic maintenance works on NR1 and NR6 will achieve small impacts on many vehicles. On NR1 and NR6, VOCs and VOTs will be reduced by 5%–7%. Vehicle operating costs were determined by HDM4, using the parameters described in Table 4. The value of passengers' working time was estimated to be on average \$0.75/hour for motorcyclists, \$2.98/hour for car users, and \$0.41/hour for bus users.[2]

Table 4: Main Vehicle Fleet Parameters and Operating Costs

Road Vehicle Fleet	Motor-cycle	Car	Small Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Economic unit costs (\$)							
New vehicle cost/vehicle	700.00	22,000.00	14,500.00	22,000.00	15,000.00	22,000.00	45,000.00
New Tire	9.00	45.00	117.00	197.00	144.00	197.00	220.00
Fuel cost/liter	0.64	0.64	0.56	0.56	0.56	0.56	0.56
Maintenance labor cost/hour	2.66	5.10	5.10	5.10	5.10	5.10	5.10
Crew cost/hour			3.59	4.35	3.59	4.35	5.07
Utilization							
Kilometers driven per year	6,000	15,000	35,000	35,000	30,000	40,000	45,000
Hours driven per year	600	750	1,600	1,750	2,000	2,000	2,000
Service life (years)	8	12	10	10	8	12	12

Source: Asian Development Bank estimates.

11. **Transport externalities.** Better riding conditions on the national roads after their periodic maintenance will marginally reduce vehicle carbon dioxide emissions by 1.6% or 45,687 tons over a 10-year period.[3]

12. **Reduction in road crashes**. The wider road pavement and shoulders will help better segregate slow- and fast-moving vehicles, and the road safety component will reduce accident rates and severity in selected vulnerable areas. The positive effects on road safety may however be offset by the higher vehicle speeds. An exact evaluation of the scale of the impact was not possible because of a lack of localized data on accidents. The net impact on the project evaluation is expected to remain minor and was ignored.

[2] Based on actual wage rates at shadow prices in the project area. Nonworking time was valued at 33% of working time. Source: Pyunghwa Engineering Consultants Company. 2016. *Draft Final Report: ADB TA 8784-CAM: Second Road Asset Management Project*. Seoul.

[3] Carbon dioxide emissions modeling carried out also using the Highway Development and Management (HDM4) software. Calculations are limited to fuel-related consumption by road vehicles

E. Cost–Benefit Analysis

13. **Economic rate of return.** The economic internal rate of return (EIRR) of the project's costs and benefits is 17.9%, with a net present value (NPV) of $27.1 million at a discount rate of 9.0%. Including the economic value of savings in carbon dioxide emissions in the evaluation increases the EIRR to 18.2% and the NPV to $27.9 million. The two road investments are economically viable, with EIRRs between 15.0% and 19.9% (Table 5). Table 6 provides a summary of economic cost and benefit flows.

Table 5: Economic Analysis Summary

Item	**EIRR** (%)	**NPV** ($ million)
NR1	19.9	19.6
NR6	15.0	7.4
Overall project	**17.9**	**27.1**

EIRR = economic internal rate of return, NPV = net present value.
Note: Net present value calculated with a 9% discount rate.
Source: Asian Development Bank estimates.

Table 6: Economic Cost and Benefit Flows
($ million)

			Existing Traffic Benefits		
Year	**Capital Costs**	**Maintenance Costs**	**Operating Cost Savings**	**Time Savings**	**Total**
2018	21.2	(0.1)			(21.0)
2019	31.7	(3.5)	3.1	0.4	(24.8)
2020		(2.0)	4.5	0.5	7.0
2021		(0.0)	5.6	0.6	6.2
2022		(0.1)	6.5	0.7	7.3
2023		(0.1)	7.6	0.8	8.5
2024		(0.1)	9.0	1.0	10.1
2025		(0.1)	10.6	1.1	11.9
2026		(5.4)	12.8	1.4	19.6
2027		0.3	14.0	1.5	15.2
2028		(0.1)	15.7	1.8	17.6
2029		0.2	17.5	2.1	19.4
2030		(0.1)	19.0	2.2	21.2
NPV at 9%	**46.1**	**(7.2)**	**64.7**	**7.3**	**27.1**

( ) = negative, NPV = net present value.
Source: Asian Development Bank estimates.

14. **Sensitivity.** The project's rate of return is robust to increases in capital costs of 20% (EIRR of 14.1%; switching value of 59%) and to a reduction of benefits by 20% (EIRR of 13.9%, switching value of –41%). A 2-year increase in project implementation leads to a limited reduction of the EIRR (16.4%). An unlikely combination of all three scenarios reduces the EIRR to 9.1%, which remains marginally above the 9.0% discount rate.

15. **Sustainability**. The project will rejuvenate the targeted road pavements, which will reduce their medium-term routine and repair costs, and will postpone by 7–10 years the next time periodic maintenance is required. The net fiscal impact on the highway agency is positive.