ADB

Economic Analysis

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Improvement, Rehabilitation and Maintenance of Kandy – Jaffna Road (A009) from Naula to Dambulla

Prepared by the Road Development Authority, Ministry of Highways for the Asian Development Bank.

Asian Development Bank

INTEGRATED ROAD INVESTMENT PROGRAM

ECONOMIC ANALYSIS

A009: Kandy - Jaffna Road (Section From 58 + 000 km To 72 + 710 km)

A. Introduction

1. **Project Overview.** Asian Development Bank (ADB) provides financial assistance to the Government of Sri Lanka for rehabilitating selected rural, and national roads under two phases of Integrated Road Investment Program (iRoad). The first phase, was launched in 2014 and implemented in Central; North Central and North Western; Sabaragamuwa; Southern; and Western provinces to (i) upgrade and maintain about 2,200 km of rural access roads to all-weather standard and (ii) rehabilitate and maintain about 400 km of national roads to a good condition. When this phase advances, original scope was revised to include 3,105 km of rural access roads. Eventually the first phase of the program awarded 3,130 km of roads for civil works under the conventional road construction contracts while another 77 km under the road management contracts. About 2,500 km, awarded under the conventional road contracts, already have been upgraded and currently under 3 year performance based maintenance period. The second phase of the program was launched in 2016 to (i) upgrade and maintain about 3,400 km of rural access roads to an all-weather standard and (ii) rehabilitate and maintain about 340 km to a good condition of national roads in Eastern, Northern, Uva, and Western provinces. Under this phase, civil works in all provinces now have been commenced and in progress.

2. **Proposed project road section.** The Government has proposed to include the national road section of A009: Kandy - Jaffna road from Naula (58+000 km) to Dambulla (72+710) km as a scope change to the first phase of iRoad program under the road management contracts. This road section, located on a flat terrain in Central Province, becomes the main entry to Dambulla town area from the western part of the country. Currently it is in sub-standard two lane configuration (7.0 m carriageway with 0.5 m hard shoulders) except the last 685 m (72+025 km to 72+710 km) which is in four lane configuration. The whole section is surfaced with asphalt concrete and maintains a fairly deteriorated pavement condition with a roughness value varying between 4.5 -5.5 m/km. The proposed rehabilitation targets to improve the geometry, pavement, shoulders, drainages and safety features of the project road section while surfacing the carriageway with asphalt concrete. The rehabilitation would only widen the existing carriageway from 70+750 km to 72+025 km to four lanes while limiting the rest to the existing width. The proposed project road section has been considered as one construction package as it is only 14.71 km in length, but divided into three homogeneous sub-sections in terms of traffic flow at 62+173 km and 70+750 km to improve the comprehensiveness of the economic analysis herein.

B. Demand Analysis

3. **Demand categorization.** Traffic demand estimate consists of (a) normal traffic passing along the project road despite it is improved or not; (b) diverted traffic shifting from another route in competition; and (c) generated traffic occurring additionally in response to road improvement. The base-year traffic only consists of the normal traffic while the future traffic, estimating over the project benefit period, includes all above three categories.

4. **Base year traffic.** The base-year traffic (2020) for the project road section were estimated by homogeneous sub-sections based on the results of classified traffic counts provided by the Road Development Authority (RDA). These field counts were first averaged to estimate the average daily traffic (ADT) and then converted to the annual average daily traffic

(AADT) by multiplying with an appropriate seasonal factor. Due to non-availability of historical traffic data, a seasonal factor of 1.0 was assumed in this estimation. The estimated AADTs for each homogeneous sub-section are summarized in Table 1 by vehicle types.

Table 1: Base Year Traffic (2020) for the Homogeneous Sub-Sections
(AADT, Number of Vehicles/day)

Vehicle Types	58+000 – 62+173	62+173 – 70+750	70+750 – 72+710
Motor Cycles	4,001	2,057	3,264
Three wheelers	2,612	1,343	2,132
Cars	2,228	1,146	1,818
Vans	2,332	1,199	1,903
Small Buses	231	119	188
Standard Buses	1,096	564	895
Light Goods Vehicles	1,134	583	926
Medium Goods Vehicles	1,487	764	1,213
Heavy Goods Vehicles	86	44	70
Multi-Axle Vehicles	16	8	13
Farm Vehicles	26	14	22
AADT (Motorized)	***15,249***	***7841***	***12,444***
Bicycles	455	230	375
AADT (Non-Motorized)	***455***	***230***	***375***

AADT = Average Annual Daily Traffic
Source: Planning Division, Road Development Authority

5. **Future traffic.** The future traffic is an aggregation of the normal, diverted and generated traffic growing over time in response to the socio-economic development of the project influenced area. RDA has forecasted the future traffic for the project road section by using STRADA (System Traffic Demand Analysis) model developed based on the four-step demand forecasting method (trip generation, trip distribution, and model choice & traffic assignment) in traffic theories. This forecasting is for 'without project scenario' and hence only takes the normal traffic into account. Hence the diverted and generated traffic were needed to estimate separately and incorporate to the analysis.

6. The model, calibrated with present road network features and user characteristics, generates a user origin-destination matrix enabling to estimate present vehicular demand on the project road section. The zonal trip generations which contribute to the vehicular demand on project road section are related to zonal socio-economic parameters such as population, vehicular population, labor force and regional production and thereby build-up a best-fitted correlation. Assuming such found correlation will remain unchanged, trip generations and in turn vehicular demand on the project road section are estimated for future years by using predicted socio-economic parameters as applicable. Such forecasted traffic till 2045 presents in Table 2 as AADTs in five year intervals for the homogeneous sub-sections. It should be noted that this forecasting have been taken likely impact of COVID-19 into account.

Table 2: Forecasted Traffic for Project Benefit Period
(AADT, Number of Vehicles/day)

Year	58+000 – 62+173		62+173 – 70+750		70+750 – 72+710	
	MT	NMT	MT	NMT	MT	NMT
2020	15,249	455	7,841	230	12,444	375
2025	16,759	497	13,507	251	12,187	410
2030	21,519	544	16,637	275	13,554	448
2035	25,943	586	19,200	296	16,375	483
2040	30,169	631	21,170	319	19,014	520
2045	31,678	680	21,758	344	20,018	560

AADT = Average Annual Daily Traffic, MT = Motorized, NMT = Non-Motorized
Source: Planning Division, Road Development Authority

7. Since diverted and generated traffic have not been properly evaluated, they were added to forecast as a percentage of the normal traffic in respective years. As there are no routes in competition with the selected project road, the diverted traffic was not considered in this analysis. However, the generated traffic estimated at 5% of the normal traffic was applied as road rehabilitation would improve the inter-regional mobility by reducing the travel time.

C. Economic Analysis

8. **Methodology and assumptions.** The economic analysis follows ADB's guidelines and uses the HDM-4 model to compare transport costs for road agency and road users under with- and without-project scenarios.[1]The without-project scenario includes routine and periodic maintenance for the project road section and no capacity improvement whereas the with-project scenario includes rehabilitation or up-gradation to the specified standard together with required routine and periodic maintenance.

9. The economic analysis was conducted in the domestic price numeraire presented in the national currency and for a 22-year benefit period which includes a 2 year construction period for the package commencing from the first quarter of year 2021. The constructed road section would be opened for traffic in the first quarter of 2023. The project includes newly built structures that have an asset life much longer than the benefit period. Hence, the salvage value of 10% at the end of the benefit period was estimated assuming a 40-year life span for the structures. The analysis used 2020 constant prices and a discount rate of 9% to actualize net benefits. A shadow exchange rate factor of 1.033 estimated from trade data was used for approximating the domestic price equivalent of tradable inputs and outputs.[2] A shadow wage rate factor of 1.0 for skilled and semiskilled workers; and 0.72 for unskilled labor were estimated based on current wages of construction industry.

10. **Construction cost.** The construction cost for the project road section is based on their engineer's financial estimate. This estimate includes those for civil works, environmental impact mitigation (to control dust, noise, waste, and traffic disruption caused by construction), shifting utilities, quality control, construction supervision, project management, and contingencies. Such estimated financial cost of the construction was converted to economic cost by excluding financial contingencies for price escalation and applying the shadow exchange factor and shadow wage rate factors to the remainder as stipulated in the ADB guidelines (footnote 1).The estimated financial and economic construction costs per km for the project road section are SLRs 98,609,595 and SLRs 80,007,288 respectively. This estimated cost will be disbursed as 40% in 2021, and 60% in 2022 during the construction.

11. **Maintenance costs.** The costs for periodic and routine maintenance were calculated based on Highway Schedule of Rates (HSR) and recent road expenditure details. For asphalt concrete roads, cost for periodic overlay was estimated at SLRs 1,700 per m^2 for 40 mm thickness. Unit prices for treatments were estimated at SLRs 450 per m^2 for patching, SLRs 1,200 per m^2 for edge repair, SLRs 330 per m^2 for crack sealing, SLRs 1,200 per km for shoulders. The regular routine maintenance cost for weeding, cleaning ditches, and re-painting markings etc, was estimated at SLRs 45,000 and SLRs 20,000 per annum for with and without project scenarios.

12. **Project benefits.** The economic analysis presented herein estimates four categories of tangible benefits: (i) savings in vehicle operating costs due to improved road conditions, (ii) savings in travel time due to increased travel speeds, (iii) savings in carbon dioxide (CO_2) emission cost, and (iv) savings in non-motorized (NMT) user costs. In addition to tangible benefits, the project will accelerate the economic growth of its influenced areas as it provides improved access to social, health, education, market, employment facilities for the inhabitants. Moreover, there would be a likely reduction in road accidents following the improvements in

[1] Asian Development Bank. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.
[2] International Monetary Fund. http://data.imf.org/regular.aspx?key=61545859 (accessed July 2020).

road geometry, pavement, road signs and markings etc. Ignorance of these intangible benefits, suggests that project's feasibility indicators are certainly stronger than the derived herein.

13. **Travel time cost savings.** The average operating speed on the proposed road section is currently about 30 - 35 km/h. Following the proposed rehabilitation, it would only increase by 5 -10 km/h as the project mainly targets to improve the road pavement condition but not the capacity. The HDM 4 assesses the value of time saved by comparing travel times in the with- and without-project scenarios weighted with unit time values of passengers. The unit time values of passengers used in the HDM 4 are given in Table 3. Those values were estimated using current income levels and relevant published data in a methodology recommended by a government manual,[3] which defines users of public and private transport by income categories.

Table 3: Value of Travel Time for Passengers and Occupancy Rates, 2020

Vehicle Type	Value of Work Time (SLRs/hr)	Value of Non-work Time (SLRs/hr)	Occupancy Rate
Two- and three-wheeler	123.6	20.5	1.5
Car/Van	650.6	108.4	Car: 2.5/Van: 4.0
Public transport	64.4	10.7	25.0–35.0

hr = hour, SLRs = Sri Lanka rupees.
Source: Consultant's estimates.

14. **Cargo delay.** The value of cargo delay per hour was derived as the opportunity cost of capital tied up in delayed cargo (value of cargo multiplied by the interest rate) and was estimated at SLRs 11.56 for light trucks, SLRs 25.43 for medium trucks, SLRs 42.38 for heavy trucks and SLRs 77.05 for multi-axle trucks. These estimations assume cargo values per ton to range between of SLRs 250,000 – SLRs 300,000 across different vehicle categories, an interest rate of 12%, and two-thirds of cargo vehicles benefited.

15. **Vehicle operating cost savings.** The HDM 4 was used to estimate the vehicle operating cost (VOC) for the traffic under the with- and without-project scenarios. The model estimates VOCs taking into account the speed, travel time, surface quality, road congestion, vehicle characteristics, and economic prices (including capital cost, maintenance cost, crew cost, fuel, and lubricants). The net reductions in VOCs are presented as savings. Vehicle characteristics are as per the manufacturer's specifications while their utilization and economic prices are derived from recent road user cost studies and market surveys.

16. **CO_2 emission savings**. The emission model built into HDM 4 is capable of estimating the net annual change (increase or decrease) of CO_2 in terms of quantity when the project is implemented. For this estimation, the model primarily uses input characteristics data for vehicle fleet and road conditions. Such estimated savings in quantity were monetized by using a unit value of $36.30 per tonne of CO_2 in 2016 prices and were expected to increase by 2% annually in real terms (footnote 1).

17. **NMT Savings.** These savings were estimated only for bicycles in terms of VOC and time savings. HDM 4 predicts that bicycles are gained a speed increase of about 2-3 km/hr after improvement of the project road section. This gain is translated to the time saving by using unit time value of SLRs 22/hour and average occupancy of 1.1 passengers. The model estimates savings in operating cost by using key inputs of operating weight of 100 kg, average life of 10 years; annual working hours of 150 km and annual km ridden of 2500.

18. **Economic feasibility.** The results of the economic analysis for the project road section are presented in terms of economic internal rate of return (EIRR) and economic net present value (ENPV) at 9% discount rate in Table 4. The base-case result demonstrates that project road section is economically feasible for implementation since its EIRR value of 15.5% is above the threshold values of 9%. This conclusion is further affirmed by the sensitivity analysis conducted for testing the robustness of economic feasibility against uncertainties in estimated

[3] Government of Sri Lanka, Ministry of Finance and Planning. 2001. *Assessing public investment in the transport sector*. Colombo.

costs and benefits associated with the proposed project road section. The Sensitivity analysis was carried out with respect to adverse changes in the estimated construction costs (15% increase), project benefits (15% decrease) and combination of those two cases (worst case) that can negatively influence in the project's economic feasibility. The results of sensitivity analysis given in Table 4 indicate that proposed project road section remains economically feasible in all sensitivity scenarios including the worst-case.

Table 4: Results of Economic Analysis & Sensitivity Analysis

Package	Section (Chainages, km)	EIRR (%)				ENPV @ 9% Base Case (SLRs million)
		Base Case	+15% Cost	-15% Benefit	Worst Case	
A009: Kandy – Jaffna (Naula to Dambulla)	58+000 – 72+710	15.5	13.5	13.2	11.2	675.3

EIRR = economic internal rate of return, ENPV = economic net present value
Source: Consultant's estimates.

19. Table 5 provides annual cost –benefit streams for the project road section.

Table 5: Cost–Benefit Stream for the Project Road Section (58+000 km – 72+710 km)
(SLRs million, 2020 constant prices)

Year	Capital Costs	Recurrent Costs	VOC Savings	VOTT Savings	NMT Saving	CO_2 Savings	Net Benefits	Discounted Benefits
2021	470.8	0.0	0.0	0.0	0.0	0.0	(470.8)	(470.8)
2022	706.1	(92.9)	0.0	0.0	0.0	0.0	(613.3)	(562.6)
2023	0.0	0.4	59.7	83.8	0.4	1.9	145.4	122.4
2024	0.0	0.4	61.1	81.4	0.4	(1.5)	140.9	108.8
2025	0.0	0.4	69.3	87.1	0.4	(1.5)	154.9	109.7
2026	0.0	0.4	77.0	92.8	0.4	(1.5)	168.4	109.4
2027	0.0	0.4	83.7	97.3	0.4	(1.6)	179.6	107.1
2028	0.0	0.4	92.3	103.0	0.4	(1.5)	193.8	106.0
2029	0.0	0.4	102.7	109.2	0.5	(1.5)	210.5	105.6
2030	0.0	0.4	112.6	113.8	0.5	(1.2)	225.3	103.7
2031	0.0	0.4	124.8	118.8	0.5	(1.2)	242.6	102.5
2032	0.0	56.3	137.0	123.3	0.5	(1.2)	203.3	78.8
2033	0.0	0.4	90.2	125.4	0.4	(1.9)	213.8	76.0
2034	0.0	0.4	97.6	130.9	0.4	(1.5)	227.0	74.1
2035	0.0	0.4	105.8	134.4	0.4	(1.2)	239.0	71.5
2036	0.0	0.4	111.8	134.2	0.4	(1.4)	244.7	67.2
2037	0.0	0.4	120.0	138.0	0.5	(1.5)	256.6	64.6
2038	0.0	0.4	129.2	142.3	0.5	(1.5)	270.1	62.4
2039	0.0	0.4	140.7	146.9	0.5	(1.5)	286.3	60.7
2040	0.0	0.4	151.3	148.4	0.6	(1.6)	298.3	58.0
2041	0.0	0.4	164.3	149.6	0.6	(1.5)	312.6	55.8
2042	(61.8)	0.4	181.1	150.8	0.6	(1.4)	392.6	64.3
TOTAL	**1,115.1**	**(29.5)**	**2,212.4**	**2,411.3**	**9.2**	**(25.6)**	**3,521.7**	**675.3**
							ENPV @ 9%	**675.3**
							EIRR	**15.5%**

( ) = negative, CO_2 = carbon dioxide, EIRR = economic internal rate of return, ENPV = economic net present value, NMT = Non-Motorized Traffic, VOC = vehicle operating cost, VOTT = value of travel time.
Source: Consultant's Estimates.

D. Conclusions and recommendations

20. The project road section is economically feasible for implementation as it records an EIRR value above the threshold value of 9% at base-case and remains robust at all possible negative sensitivity scenarios, including the worst case. Thus it is recommended to proceed the project for its construction without a delay to maximize the anticipated benefits.