# ECONOMIC AND FINANCIAL ANALYSIS

1. The economic internal rate of return (EIRR) for the project is calculated as the difference between the capital and road user costs with and without the project. The economic analysis including sensitive analysis found that the project is highly viable economically.

2. The approach to the financial analysis follows the Guidelines for the Financial Analysis of Projects of the Asian Development Bank (ADB).[1] Given that the project does not generate its own revenue, the analysis focuses on the executing agency's financial capacity to meet the recurrent costs of operating and maintaining the roads under its purview in a sustainable manner. The assessment found that the financial position of the executing agency is adequate to ensure the financial sustainability of the rural road network.

## A. Prices

3. Costs and benefits are calculated using economic costs based on border prices for traded goods and services, and domestic market prices net of taxes and subsidies for nontraded items. The prices are in mid-2017 United States dollars. The net-of-tax economic cost of regular gasoline is calculated at $0.80/liter and diesel at $0.72/liter based on border prices. Lubricant costs are estimated at about $3.15/liter for motorcycles and $5.25/liter for four-wheel drives. Passenger time values are likely to increase in real terms, in step with increasing per capita income; an allowance is made to reflect this. Underemployment of unskilled laborers is considerable and reflected in adopting a shadow price of the market rate for unskilled labor of 0.8. Altogether, a conversion factor of 0.85 was applied to the financial costs of capital.

## B. Traffic Demand Analysis

4. Traffic is estimated for each road section evaluated. Base-year traffic is estimated using 2-day manual classified counts carried out on all study roads, with more than one count site used in some cases. These were verified by moving-observer counts, which were used to check on changes in traffic flow along the roads, and then adjusted to an annual average daily traffic basis. The growth rate can be related linearly to anticipated gross domestic product (GDP). This is normally preferable because it incorporates changes in overall economic activity. On that basis, traffic growth is forecast by applying elasticities of demand for transport with respect to GDP growth, with growth rates forecast for three separate time periods over the evaluation period. In this study, 2017 is the base year of traffic count surveys. Hence, the growth rate of real GDP is also considered from 2016. An average annual growth rate of 7.0% is used for 2017–2020 based on ADB's economic forecasts;[2] the medium- and long-term predicted growth rates are those used by the Economic Research Service of the United States Department of Agriculture, with 6.8% for 2020–2025 and 7.6% for 2025–2030.[3] Using these growth rates of GDP and assumed elasticities of demand for vehicles, the normal traffic growth rates are calculated (Table 1).

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[1] ADB. 2005. *Financial Management and Analysis of Projects.* Manila.

[2] ADB. 2017. *Asian Development Outlook 2017*. Manila.

[3] Economic Research Service, United States Department of Agriculture. 2013. *Historical and Projected Gross Domestic Product per Capita for Baseline Countries/Regions (in 2005 dollars) 2000–2030.* Washington, DC.

**Table 1: Normal Traffic Growth Rates**

| Mode of Traffic | 2017–2020 | 2020–2025 | 2025–2030 |
|---|---|---|---|
| Motorcycle | 10.2 | 11.6 | 12.9 |
| Passenger | 7.2 | 8.2 | 9.1 |
| Freight | 6.6 | 7.5 | 8.3 |

Source: Asian Development Bank.

5. In addition to normal growth, traffic is assumed to increase by up to 15% for motorcycle traffic, 20% for passenger cars, and 10% for freight traffic once roads are sealed, to allow for the impact of road user cost reductions and all-weather accessibility.

## C. Evaluation Model

6. The economic analysis of upgrading the roads is based on the Highway Development and Management Tool (HDM-4), using the latest version available (version 2.08). The model simulates the road condition for each road section, year by year, considering (i) road deterioration, which is the prediction of pavement deterioration and surface roughness; (ii) works effect, whereby the effects of road works on pavement condition are simulated and the corresponding costs determined; and (iii) road user effects, with the costs of vehicle operation and travel time determined to estimate the costs and benefits of alternative road improvement and maintenance strategies.

## D. Benefits

7. Two types of benefits are considered: (i) savings in travel time and (ii) savings in vehicle operating cost (VOC). The residual value of the works is considered as a benefit from road improvement, representing the remaining asset value of the works, and is included at the end of the evaluation period, although the impact of the result is small when an evaluation period of more than 20 years is used. The residual value in this study is assumed to be zero.

8. The design of the road pavement can be considered in terms of traffic, surfacing, basic structure, climate conditions, and lifecycle cost.

9. Travel time savings are obtained when road improvements lead to an increase in vehicle speeds, thus reducing the journey time of passengers. Travel time savings are the result of the increase in vehicle speeds on the improved roads. The estimate of such savings is based on the gross national income per head, which is estimated at $1,140 in 2016.[4] Assuming that 45% of the population is economically active and on average works 2,000 hours per year, the average hourly income in 2009 becomes $1.27. This is much higher than typical rural incomes in Cambodia, so a value of $0.5 per hour was used for the working time of motorcycle users and public transport passengers. For passengers in cars and four-wheel drive vehicles, which typically are in the highest 20% income group, an average working time income of $2 per hour was assumed. Nonwork travel time (50% of total travel time for car and four-wheel drive passengers and 30% for others) is valued at $0.3 per hour for car and four-wheel drive passengers and at $0.15 for other passengers. Freight time cost savings were not considered.

10. VOC savings will be estimated using HDM-4. VOC is a basic item in road project evaluations and the main source of benefits. The HDM-4 model predicts the consumption of

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[4] ADB. 2017. *Key Indicators for Asia and the Pacific 2017*. Manila.

resources for each component of VOC per kilometer. The model takes into account a wide range of factors, including the surface condition and geometry of each road section, and the characteristics of representative vehicles.

11. The VOC savings stem primarily from reduced surface roughness and increased travel speed on the improved roads. In this study, VOC savings are estimated for 14 vehicle types commonly used in rural Cambodia, including conventional motorized vehicles, nonmotorized vehicles, and unconventional motorized vehicles (Table 2).

**Table 2: Vehicle Operating Cost Data**

| | | | Vehicle Characteristics | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Average Life** | **Vehicle** | **Utilization** | **Economic** | **VOC** ($/km) | | |
| **Vehicle Type** | **ESA** | (years) | **Hours** | (km) | **Price** ($) | **IRI 3** | **IRI 10** | **IRI 15** |
| Bicycle | 0.000 | 10 | 150 | 2,500 | 42 | 0.00 | 0.00 | 0.01 |
| Animal cart | 0.000 | 6 | 1,300 | 4,000 | 315 | 0.00 | 0.00 | 0.00 |
| Motorcycle | 0.000 | 8 | 600 | 8,000 | 735 | 0.03 | 0.04 | 0.05 |
| Motorcycle + trailer | 0.000 | 10 | 600 | 8,000 | 893 | 0.04 | 0.05 | 0.06 |
| Car | 0.004 | 12 | 750 | 15,000 | 23,100 | 0.25 | 0.31 | 0.37 |
| Jeep/4WD | 0.010 | 10 | 750 | 25,000 | 50,925 | 0.35 | 0.54 | 0.68 |
| Pick-up | 0.050 | 10 | 1,250 | 25,000 | 12,600 | 0.24 | 0.34 | 0.41 |
| Minibus | 0.040 | 10 | 1,600 | 35,000 | 15,225 | 0.20 | 0.27 | 0.33 |
| Bus | 0.700 | 10 | 1,750 | 35,000 | 23,100 | 0.33 | 0.46 | 0.58 |
| Small koyun | 0.050 | 10 | 400 | 6,000 | 1,575 | 0.07 | 0.08 | 0.09 |
| Large koyun | 0.200 | 10 | 400 | 6,000 | 3,150 | 0.16 | 0.29 | 0.34 |
| Light truck | 0.200 | 8 | 1,600 | 30,000 | 15,750 | 0.24 | 0.33 | 0.40 |
| Medium truck | 0.800 | 12 | 2,000 | 40,000 | 23,100 | 0.32 | 0.46 | 0.56 |
| Heavy truck | 3.500 | 12 | 2,400 | 45,000 | 47,250 | 0.59 | 0.83 | 1.00 |

4WD = four-wheel drive; ESA = equivalent standard axle; km = kilometer; IRI = international roughness index; VOC = vehicle operating cost.
Source: Asian Development Bank.

## E. Project Costs

12. The major capital costs are the cost of civil construction works proposed for each road section to upgrade it to double bituminous surface treatment (DBST) in rural areas. Using an engineering point of view, specific cost estimates are based on inventories. The cost estimate includes earthwork and allied activities, sub-base and base courses, bituminous works, structures, drainage and protection work, ancillary work, unexploded ordnance, miscellaneous, day-works schedule, contingency, as well as design and project management costs.

13. The current bridges are adequate in most cases, with many newly constructed. The cost of replacing inadequate bridges is included in the project cost. No land acquisition or resettlement costs are expected. Only minor environmental mitigation measures are expected to be required, and an allowance for any costs is included in the contingency.

14. The variation in the cost of improvement per kilometer depends on the road width, location of material available, and labor works. The financial and economic costs used for each road are shown in Table 3.

**Table 3: Road Improvement Costs**

| Code | Road Section Start | End | Road Length (km) | Width (m) | Cost of Improvement ($/km) Financial | Economic |
|---|---|---|---|---|---|---|
| KC1 | Kor | Tuek Cha | 13.5 | 8 | 112,000 | 95,000 |
| KC2 | Samdaek | Sampong Chey | 23.0 | 7 | 85,000 | 73,000 |
| KC3 | Ou Tathok | Bosthlan | 11.3 | 8 | 106,000 | 90,000 |
| KC4 | Phav | Doun Dam | 11.2 | 8 | 114,000 | 97,000 |
| KC5 | Dei kraham | Areak Tnaot | 20.1 | 8 | 105,000 | 89,000 |
| KC6 | Mer Sar Chrey | Wat lor | 21.5 | 8 | 104,000 | 89,000 |
| TBK1 | Tuol Kondaol | NR11 | 9.9 | 8 | 113,000 | 96,000 |
| TBK2 | Trapeang Phlong | Stueng Toch | 16.0 | 7 | 95,000 | 80,000 |
| TBK3 | Chhuk | Sedasenchey | 13.7 | 8 | 111,000 | 95,000 |
| TBK5 | Kondoal chrum | Char Thum | 15.1 | 8 | 110,000 | 94,000 |
| TBK6 | Suong | Phnum chan | 6.4 | 8 | 109,000 | 93,000 |
| PV1 | Lngeun | Boeng Kak | 20.2 | 8 | 117,000 | 99,000 |
| PV2 | Pou Tong | Dountei | 22.5 | 8 | 118,000 | 100,000 |
| PV3 | Svay Sokhao | Pou Rieng | 9.3 | 8 | 107,000 | 91,000 |
| PV4 | Kampongtrabek | Preah Sdach | 15.0 | 8 | 125,000 | 107,000 |
| PV5 | Kanh Chreach | Kouk Kongkandal | 5.2 | 8 | 111,000 | 94,000 |
| SVR2 | Kroulko | Wath Svaypnem | 11.0 | 8 | 113,000 | 96,000 |
| SVR3 | Pheasa Chork | Pongtek | 9.1 | 8 | 112,000 | 95,000 |
| SVR4 | PreyKearv | KomPongAmpil | 24.8 | 8 | 113,000 | 96,000 |
| SVR5 | PrasPonlea | SomYong | 11.9 | 7 | 91,000 | 77,000 |
| SVR6 | Sala Srok Chantrea | Vietnam Border | 7.8 | 8 | 113,000 | 96,000 |
| KRT1 | Chhlong | Prama | 61.3 | 8 | 118,000 | 101,000 |
| **Total** | | | **359.8** | | **110,000** | **94,000** |

KC = Kampong Cham; km = kilometer; KRT = Kratie; m = meter; NR = national road; PV = Prey Veng; SVR = Svay Rieng; TBK = Tboung Khmum.
Source: Asian Development Bank.

15. Routine and periodic maintenance were considered. The maintenance operations for each are determined within HDM-4 according to road condition and assumed intervention standards or specified time interval. The maintenance of roads is assumed to take into account both the with- and without-project scenarios of upgrading pavement to DBST or concrete. Without the project, the laterite and/or earth road maintenance standard is applied to all road sections, with regraveling every 3 years and grading every 365 days.

16. Purely routine maintenance procedures, such as drain clearance, grass cutting, and traffic sign repair, would be similar in both the without- and with-project cases. As such, they do not affect the evaluation result, and a nominal estimate of annual costs per km of road is applied. The criteria for the with- and without-project cases, which are based on previous studies or actual works, are shown in Table 4, and the costs in Table 5.

**Table 4: Road Maintenance and Improvement Criteria**

| Items | Standard | Work Items | Criteria |
|---|---|---|---|
| Maintenance | Laterite or earth road maintenance<br>Maintenance before upgrading | Laterite or earth graveling<br>Laterite or earth grading<br>Routine maintenance (miscellaneous) | Interval >= 3 years<br>Interval >= 365 days<br>Interval >= 1 year |
| | Maintenance after upgrading to DBST or concrete | Overlay of asphalt concrete<br>Concrete replacement | Year >= 2025<br>Interval >= 8 years |
| | | Resealing with SBST<br>Pothole patching, 100% annually | Interval >= 5 years<br>Interval >= 1 year |

| Items | Standard | Work Items | Criteria |
|---|---|---|---|
| | | Routine maintenance (miscellaneous) | Interval >= 1 year |
| Improvement | Upgrading to DBST<br>Upgrading to concrete | 30 mm surface dressing<br>150 mm thickness of slab without reinforcement | Year >= 2015<br>Year >= 2015 |

DBST = double bituminous surface treatment; mm = millimeter; SBST = single bituminous surface treatment.
Source: ADB. 2011. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the Kingdom of Cambodia for the Provincial Road Implementation Project.* Manila (Loan 2839-CAM).

**Table 5: Unit Cost of Road Maintenance**

| Work Items | Unit | Economic Cost ($) |
|---|---|---|
| **Laterite road** | | |
| Graveling | $m^3$ | 10.0 |
| Grading | km | 120.0 |
| Annual routine maintenance | km | 350.0 |
| **DBST road** | | |
| Crack sealing | $m^2$ | 2.0 |
| Pothole patching | $m^2$ | 9.5 |
| Edge repair | $m^2$ | 7.5 |
| SBST reseal | $m^2$ | 3.0 |
| Annual routine maintenance | km | 350.0 |

DBST = double bituminous surface treatment; km = kilometer; $m^2$ = square meter; $m^3$ = cubic meter; SBST = single bituminous surface treatment.
Source: ADB. 2011. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the Kingdom of Cambodia for the Provincial Road Implementation Project.* Manila (Loan 2839-CAM).

## F. Economic Analysis Results

17. The results of the economic evaluation for all project roads are summarized in Table 6. When all road sections are combined and evaluated as a single project considering a 10-year evaluation period, the EIRR is 40.1% and the net present value at a discount rate of 6% is $79.0 million. All road sections are viable with EIRRs of 15.4%–70.2%. The summary of economic costs and benefit flows of the project is shown in Table 7.

**Table 6: Cost–Benefit Analysis for All Road Projects**

| Item | Indicator |
|---|---|
| Economic internal rate of return (%) | 40.1 |
| Cost–benefit ratio | 7.0 |
| Net present value ($ million) | 79.0 |

Source: Asian Development Bank.

18. The project will also result in net savings of carbon dioxide ($CO_2$) emissions from vehicles by about 340,000 tons over a 10-year period. Sealing the roads will reduce vehicle emissions by more than 20%, which more than balances the increase in emissions linked to generated traffic. The net present value of the economic benefit is $1.3 million, considering a value of $CO_2$ emission savings of $36.3 per ton.[5] Including $CO_2$ emission savings in the analysis would raise the EIRR to 40.8%.

[5] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.

**Table 7: Summary of Economic Costs and Benefit Flows** ($ million)

| | Cost | | Benefits | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Normal Traffic | | | Generated Traffic | | |
| Year | Capital Works | Recurrent Works | VOC Savings | Time Savings | NMT Savings | VOC Savings | Time Savings | Total |
| 2019 | 15.2 | (2.3) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **(12.9)** |
| 2020 | 15.2 | 0.0 | (5.0) | (1.1) | (0.1) | 0.0 | 0.0 | **(21.4)** |
| 2021 | 0.0 | 0.0 | 9.5 | 1.6 | 0.1 | 0.5 | 0.1 | **11.9** |
| 2022 | 0.0 | (2.4) | 13.6 | 2.5 | 0.2 | 0.8 | 0.2 | **19.6** |
| 2023 | 0.0 | 0.0 | 7.9 | 1.2 | 0.1 | 0.4 | 0.1 | **9.7** |
| 2024 | 0.0 | 0.0 | 14.3 | 2.6 | 0.2 | 0.8 | 0.2 | **18.2** |
| 2025 | 5.5 | (2.4) | 19.6 | 3.8 | 0.2 | 1.2 | 0.3 | **21.9** |
| 2026 | 0.0 | 0.0 | 12.0 | 2.0 | 0.1 | 0.7 | 0.1 | **15.0** |
| 2027 | 0.0 | 0.0 | 21.7 | 4.3 | 0.2 | 1.3 | 0.3 | **27.8** |
| 2028 | 19.2 | (2.4) | 27.8 | 5.8 | 0.2 | 1.7 | 0.4 | **19.1** |
| 2029 | 0.0 | 0.0 | 20.3 | 3.8 | 0.1 | 1.2 | 0.3 | **25.8** |
| 2030 | 0.0 | 0.0 | 33.6 | 7.0 | 0.2 | 2.1 | 0.5 | **43.3** |

( ) = negative value; NMT = nonmotorized traffic; VOC = vehicle operating cost.
Note: The negative values in the Cost columns indicate savings in periodic and/or routine maintenance costs that would be incurred in the base case.
Source: Asian Development Bank.

19. The EIRR was analyzed for changes in the benefit and cost streams using a sensitivity analysis and calculating switching values, i.e., the percentage change in a variable that causes the EIRR to be 6% (Table 8).

**Table 8: Sensitivity Analysis**

| **Scenario** | **EIRR** (%) | **NPV** ($ million) | **Switching Value** (%) |
|---|---|---|---|
| Base case | 40.1 | 79.0 | |
| Costs increase by 70% | 24.3 | 50.6 | 240.0 |
| VOC decreases by 70% | 17.8 | 13.5 | (90.0) |
| No time benefits | 35.9 | 62.4 | |
| No traffic generated | 38.7 | 73.5 | |
| Costs increase by 50%, VOC decreases by 50% | 14.6 | 11.4 | |

( ) = negative, EIRR = economic internal rate of return, NPV = net present value, VOC = vehicle operating cost.
Source: Asian Development Bank.

20. The sensitivity analysis indicates that the EIRR is more sensitive to traffic changes, either base-year traffic or traffic growth rate, than to costs or VOC. In the severe case of costs increasing by 50% and VOC declining by 50%, the EIRR remains at 14.6%, which is still higher than the 6% threshold. The risk analysis shows that the project is highly viable economically.

## G. Financial Sustainability Analysis

21. Lack of or insufficient government funding for the maintenance of rural roads is considered a moderate risk. The project is to rehabilitate the existing roads without expanding them, which will reduce the maintenance burden of project roads thanks to improved road conditions. In fact, the economic analysis shows no incremental operation and maintenance (O&M) cost for this project; rather, the budget requirement for periodical maintenance every 3 years declines. Also, at the current size of the whole rural road network, the government needs about $21 million annually for adequate O&M. The allocation of funds from the general budget totaled $19.5 million in 2017, accounting for about 93% of the O&M funding requirements.

However, the figures do not reflect maintenance work carried out by villages and communities using their own labor and financial resources.

22. Table 9 shows the development and composition of road expenditures during 2015–2017. The government has used its own resources to finance routine maintenance, while the development budget is financed by donors. During the 3-year period, the government has on average spent about $17 million per year for O&M of rural roads,[6] which, on average per year, accounted for 80% of the resources needed for O&M. Meanwhile, the O&M allocation shows a steady increase (10%) that exceeds the annual inflation rate (3%) by a large margin. The government, supported by donors, has initiated steps for the introduction of a rational and systematic O&M regime that would create and maintain the rural road network infrastructure in a cost-effective manner. To this end, an asset management system is being developed, and a review of road user charges and their allocation is underway.

**Table 9: Development of Maintenance Expenditures and Total Road Investments**

**Maintenance Requirements**

| **Surface type** | **Length** (km) | **Routine O&M** ($/km/year) | **Periodic O&M** ($/km/year) | **Routine O&M** ($/year) | **Periodic O&M** ($/year) | **Total Requirements** ($/year) |
|---|---|---|---|---|---|---|
| Earth | 10,728 | 50 | 0 | 536,415 | 0 | 536,415 |
| Gravel/laterite | 32,396 | 250 | 250 | 8,099,000 | 8,099,000 | 16,198,000 |
| DBST | 2,117 | 500 | 1,500 | 1,058,550 | 3,175,650 | 4,234,200 |
| **Total** | **45,241** | | | **9,693,965** | **11,274,650** | **20,968,615** |

| **Allocations** | **2015** | **2016** | **2017** |
|---|---|---|---|
| $ million | 14.8 | 17.7 | 19.5 |
| % of requirement | 70.6% | 84.1% | 92.7% |

DBST = double bituminous surface treatment; km = kilometer; O&M = operation and maintenance.
Source: Government of Cambodia, Ministry of Rural Development.

23. While inadequate funding of O&M is currently considered a moderate risk, more funds will have to be allocated in the future, given the government's strategy to increase the share of paved roads in the total rural road network.

24. The Ministry of Rural Development has carried out several externally financed projects to improve rural roads; all were successfully completed. The entity is equipped with qualified financial staff and financial procedures based on the Financial Management Manual published by the Ministry of Economy and Finance. The project is expected to be implemented without difficulties and the completed roads to be sustainably maintained.

[6] Routine maintenance is an annual activity and is to keep roads in serviceable condition, or prevent them from falling into disrepair prematurely. Typically, routine maintenance includes pothole repairs, edge patching, crack sealing and filling, shoulder repairs, and drainage cleaning.