ECONOMIC ANALYSIS

A. Project Costs and Benefits

1. **Project costs.** The capital costs of the Yunnan Pu'er Regional Integrated Road Network Development Project include the costs of the road works, design, supervision, and management. The economic analysis assumed a residual value of 50% after 20 years based on straight-line depreciation over a 40-year life. The new asphalt surfacing will increase road routine maintenance needs, as well as require periodic maintenance in the form of an overlay after 10 years. Financial costs were adjusted to the world price level numeraire and converted into economic costs by (i) excluding taxes, price contingencies, and financial charges; (ii) using a 0.8 shadow price for low-skilled labor costs; (iii) using a shadow price of 0.99 for other local inputs;[1] and (iv) converting nominal costs into constant 2014 yuan. The net present value (NPV) at a rate of 12% of the capital costs and maintenance costs over the project life, which was assumed to be 20 years from the opening, is CNY2,454 million for capital costs and CNY92 million for maintenance costs. Table 1 shows the economic implementation costs, inclusive of standard conversion factors, for the three project components by year—i.e., the capital expenditures required for upgrading and construction works exclusive of operating, maintenance, or periodic overhaul costs.

2. Resettlement costs were obtained from the resettlement plan prepared by the Pu'er Municipal Government. Land acquisition costs in the economic analysis represent the opportunity cost of lost agricultural production[2] over the economic analysis period.

Table 1: Economic Implementation Costs by Project Component, 2015–2018 (CNY million)

Year	Ning'er–Jiangcheng Longfu Highway	Rural Roads	Menglian–Meng'a Highway	Total
2015	465.30	15.70	295.75	776.75
2016	481.18	256.13	391.47	1,128.77
2017	480.77	252.59	294.29	1,027.65
2018	360.27	0.10	0.00	360.37
Total	**1,787.51**	**524.53**	**981.51**	**3,293.54**

Source: Asian Development Bank estimates.

3. **Travel demand.** Traffic counts were conducted along the Ning'er–Jiangcheng Highway, the Menglian–Meng'a Highway and on a previous full set of rural roads, as well as six of the proposed substitute rural roads. Flows were converted into passenger-car-equivalent units for each road in turn, taking account of both the vehicle mix specific to each road and the number of passengers per unit. Traffic along the project roads was assumed to increase at 85% of the rate of per capita income growth. Table 2 sets out the adopted annual traffic growth rates, excluding any induced traffic.

Table 2: Adopted Annual Traffic Growth Rates, 2010–2038[a]

Year	Annual Growth Rate (%)	Year	Annual Growth Rate (%)	Year	Annual Growth Rate (%)
2010	10.20	2020	8.70	2030	5.50
2011	10.20	2021	8.49	2031	5.08
2012	10.20	2022	8.28	2032	4.65

[1] This has been calculated using the methodology specified in ADB. 2003. *EDR Technical Note No. 11: Shadow Exchange Rates for Project Economic Analysis*. Manila. It is based on the most recent available date published by the International Monetary Fund International Financial Statistics and Government Finance Statistical Yearbook.

[2] The estimate of lost agricultural production due to land acquisition is provided in the project resettlement plan. The opportunity cost of lost production is estimated by assuming 5% real annual growth in production to reflect increasing productivity and conversion to crops with higher values. The stream of the projected value of lost production was discounted at 12% and adjusted by the standard conversion factor and included as a cost in the first year of implementation.

Year	Annual Growth Rate (%)	Year	Annual Growth Rate (%)	Year	Annual Growth Rate (%)
2013	10.20	2023	8.07	2033	4.23
2014	9.98	2024	7.86	2034	3.82
2015	9.77	2025	7.65	2035	3.40
2016	9.56	2026	7.22	2036	3.40
2017	9.34	2027	6.78	2037	3.40
2018	9.13	2028	6.35	2038	3.40
2019	8.92	2029	5.93		

[a] Real gross domestic product (GDP) per capita growth estimates were based on data from the Pu'er municipal government, which indicated that average annual growth in GDP per capita was 15.6% during 2009–2013. This was more than 2% higher than the national average. After 2013, it was assumed that GDP per capita would decline steadily to 9% in 2025 and from there to 4% by 2035. While these growth rates are above the projected national trend, Pu'er is starting from a lower economic level and has exceeded the growth rates for the PRC as a whole since 2009.

4. In addition to the traffic growth outlined in Table 2, allowance was made for induced traffic on some roads. A rule of half was applied to generalized cost savings for induced trips. The demand assumptions used for induced traffic were as follows:

(i) No induced traffic was assumed for the Ning'er–Jiangcheng–Longfu Highway.

(ii) For rural roads, travel costs comprising value of time (VOT) and vehicle operating cost (VOC) were estimated on each road with and without the project's improvement. A generalized cost elasticity of demand of 0.5 was applied as an estimate of induced traffic. If generalized costs decreased 40% due to the upgrading, traffic would increase by 20% on that road. Well-established research suggests that such elasticity assumptions are conservative.[3]

(iii) The analysis assumed that the project's Menglian–Meng'a Highway component, together with upgrading of border facilities with Myanmar, would result in additional cross-border traffic. Several unsuccessful attempts were made to obtain before and after data on similar roads elsewhere in Yunnan to enable analysis of the impacts of upgrading border facilities. In the absence of such data, an increase in traffic along this highway equivalent to 20% of the traffic on a section of this highway in 2017, increasing to 50% in 2037, was taken to represent the level of induced additional cross-border traffic that would travel the entire length of this project component road. Given the recent economic reforms in Myanmar, which are likely to produce a sustained increase in trade—and hence in cross-border traffic—these assumptions are likely to prove conservative. However, a sensitivity test was also conducted that excluded this additional traffic.

5. **Benefits.** The principle benefits from the road upgrading works considered by the analysis were journey time savings (evaluated using the economic VOT) and VOC savings. The rule of half was applied when estimating benefits associated with induced traffic—for every CNY1.00 of economic generalized cost savings from either VOC savings or passenger time savings that was associated with non-induced traffic, CNY0.50 was the assumed value of the savings for induced traffic. The economic benefits were based on prices corrected by the standard conversion factor of 0.99, which were input into the Highway Design and Management (HDM-IV) model. Accident savings were considered. However, due to issues with the accident rate data that was available, it was decided to exclude such potential benefits from the economic evaluation.

[3] See for example M. Hanly, J. Dargay, and Goodwin. 2002. Review of Income and Price Elasticities in the Demand for Road Traffic. *Final Report, ESRC Transport Studies Unit, Centre for Transport Studies*. University College London.

6. **Vehicle operating cost savings.** VOCs were estimated using the HDM-IV model's road user costs module. Costs were obtained on a per-kilometer basis by vehicle type, taking into account vehicle data and road characteristics. This analysis also produced speed estimates for use in the analysis. Basic data on vehicle costs were collected by Pu'er Municipal Government in 2012 and updated to 2014 prices, as shown in Table 3.

Table 3: Input Vehicle Cost Assumptions (2014 prices)

Vehicle Type	Purchase Price (CNY/vehicle)	Cost per Tire (CNY)	Fuel Cost (CNY/liter)	Oil Cost (CNY/liter)	Maintenance Labor Cost (CNY/hour)	Interest Rate (%)
Motorcycle	5,195	155.85	8.31	31.17	25.31	6.9
Car Small	103,897	831.18	8.31	31.17	50.63	6.9
Car Medium	290,911	1,246.76	8.31	31.17	50.63	6.9
4-Wheel Drive	311,691	1,246.76	8.83	31.17	50.63	6.9
Truck Light	51,948	1,038.97	8.83	31.17	50.63	6.9
Truck Medium	155,845	1,558.45	8.83	31.17	50.63	6.9
Truck Heavy	311,691	2,597.42	8.83	31.17	63.28	6.9
Tractor	20,779	623.38	8.83	31.17	50.63	6.9
Bus Light	394,808	1,038.97	8.83	31.17	50.63	6.9
Bus Medium	519,485	2,077.94	8.83	31.17	63.28	6.9

Source: Asian Development Bank estimates.

7. The HDM-IV user cost equations relate to the riding quality of the road, as measured by the International Roughness Index (IRI). The roughness of the existing road surfaces was assessed through the subjective assessment method.[4] Existing conditions on the Ning'er–Jiangcheng–Longfu Highway were in the 6–12 range on the IRI scale. Future conditions are expected to result in an IRI result of 4–5. On rural roads, the existing IRI scores are 10–20. This is expected to improve to 5–8 depending on the surfacing used. Existing conditions on the Menglian–Meng'a Highway earned an IRI score of 8, and is expected to improve to 4 after project completion. Overall, VOC savings are projected to be CNY8,214 million over the duration of the project (undiscounted). The NPV of these savings in 2015, using a 12% discount rate, was estimated to be CNY1,645 million.

8. **Value of time.** Economic VOT was estimated, based on gross domestic product (GDP) per capita in Pu'er for each year of assessment. For work-related time, GDP per capita was divided by 2,000 working hours per year to produce CNY8.665 per hour in 2014. For non-work related time, half of the work-related value was adopted, in line with standard practice—i.e., CNY4.333 in 2014. While no data was available on the split between work-related and non-work trips, it was assumed that 70% of trips would be work-related, including trips by farmers to and from market. The resulting overall economic VOT per hour per person in 2014 was (70% x CNY8.665) + (30% x CNY4.333) = CNY7.365. Table 4 shows the resultant economic VOT per person per hour for each year.

Table 4: Economic Value of Time, 2010–2038 (CNY/person/hour)

Year	EVOT	Year	EVOT	Year	EVOT
2010	4.45	2020	13.68	2030	30.87
2011	5.21	2021	15.04	2031	32.71
2012	5.89	2022	16.51	2032	34.50
2013	6.59	2023	18.08	2033	36.22
2014	7.37	2024	19.75	2034	37.84
2015	8.21	2025	21.52	2035	39.36
2016	9.14	2026	23.35	2036	40.93
2017	10.14	2027	25.22	2037	42.57
2018	11.23	2028	27.10	2038	44.27
2019	12.41	2029	28.99		

[4] World Bank. 1986. Guidelines for Conducting and Calibrating Road Roughness Measurements. *Technical Paper* No. 46. Washington, DC.

EVOT = economic value of time.
Source: Asian Development Bank estimates.

9. **Time savings.** The faster speeds allowed on the road will generate time savings for passengers and shippers. Time savings for passengers were valued (Table 5). They were assumed to grow at the same rate as Pu'er's real GDP per capita. Time savings for cargo were calculated as part of the VOCs. Passenger time savings were estimated at CNY11,224 million over the duration of the project (undiscounted). The net present value (NPV) of these savings in 2015, using a 12% discount rate, was estimated to be CNY1,834 million.

Table 5: Average Vehicle Operating Cost and Time Savings

		Without-Project Case		With-Project Case	
Vehicle Operating Costs (CNY/km)	**Distance** (km)	**IRI**	**Per Average PCU-km**	**IRI**	**Per Average PCU-km**
Ning'er–Jiangcheng–Longfu[a]	251.57/234.07	10	4.0	4	3.2
Rural roads	604.2	10-20	5.0-7.5	5-8	3.6-4.3
Menglian–Meng'a	48.8	8	3.3	4	2.9
Average Speed (kph)	**Distance** (km)	**IRI**	**Average Speed** (kph)	**IRI**	**Average Speed** (kph)
Ning'er–Jiangcheng–Longfu	251.57/234.07	10	32.4	4	44.5
Rural roads	604.2	10-20	10.8-16.2	5-8	21.6-32.4
Menglian–Meng'a	48.8	8	35.0	4	60.0

IRI = international roughness index, km = kilometer, kph = kilometer per hour, PCU = passenger car equivalent unit, VOC = vehicle operating cost.
[a] The upgrading of the Ning'er–Baka section of the Ning'er–Jiangcheng–Longfu Highway will include new alignment, shortening the effective distance from Ning'er to Baka from an estimated 52.5 km to 35.0 km.
Source: Asian Development Bank estimates.

B. Cost–Benefit Analysis

10. The economic internal rate of return (EIRR) was calculated from a starting year of 2015, concluding after 20 years of operation after the implementation of the project components (i.e. the opening of new or re-routed sections or the upgrading of pre-existing sections of road, as appropriate). Depending on actual project implementation, this is expected to be in either 2037 or 2038. The analysis estimated an overall EIRR of 14.5%, with an NPV of CNY706 million at a discount rate of 12%. The detailed evaluation by road section is in Table 6, while the details of the cost and benefits streams are shown in Table 7.

Table 6: Cost–Benefit Analysis Summary

Project Road Section	**Works Length**	**Economic Costs**[a] (CNY m)	**Economic Cost/km** (CNY m)	**ADT in 2015** (PCU's)	**ADT in 2035** (PCU's)	**NPV** (CNY m)	**EIRR** (%)
Ning'er–Jiangcheng–Longfu	234.1	1,921.4	8.2	1,181	4,791	301.9	14.2
Rural roads	604.2	713.8	1.2	42	173	97.3	14.3
Menglian–Meng'a	48.9	1,061.1	21.8	5,229	28,301	270.3	15.0
Total	**887.0**	**3,696.3**	**31.2**	**628**	**2,938**	**705.8**	**14.5**

ADT = average daily traffic, EIRR = economic internal rate of return, km = kilometer, m = million, NPV = net present value, PCU = passenger car equivalent unit.
[a] Including capital expenditure (implementation costs) and operating expenditure (operations and maintenance, plus periodic overhaul), but excluding residuals.
Source: Asian Development Bank estimates.

Table 7: Cost–Benefit Analysis Summary (CNY million)

Year	Capital Costs	Maintenance Costs	VOC Savings	Time Savings	Net Benefits
2015	776.75	0.00	0.00	0.00	(776.75)
2016	1,128.77	0.00	0.00	0.00	(1,128.77)
2017	1,027.65	3.09	18.93	14.14	(997.66)
2018	360.37	8.15	89.58	60.61	(218.33)
2019		10.86	195.43	104.20	288.77
2020		10.86	213.02	125.31	327.47
2021		10.86	231.76	150.08	370.97

Year	Capital Costs	Maintenance Costs	VOC Savings	Time Savings	Net Benefits
2022		10.86	251.66	178.99	419.78
2023		10.86	272.74	212.59	474.46
2024		10.86	295.03	251.45	535.61
2025		10.86	318.53	296.18	603.85
2026		54.45	343.24	346.60	635.39
2027		152.75	368.40	402.09	617.74
2028		10.86	393.82	462.45	845.41
2029		10.86	419.31	527.30	935.75
2030		10.86	444.69	596.06	1,029.89
2031		10.86	469.72	668.00	1,126.86
2032		10.86	494.19	742.20	1,225.52
2033		10.86	517.87	817.55	1,324.56
2034		10.86	540.54	892.84	1,422.51
2035		10.86	561.97	966.70	1,517.80
2036		10.86	581.94	1,042.60	1,613.68
2037	(565.31)	7.77	530.94	898.20	1,986.68
2038	(900.87)	2.71	304.67	345.21	1,548.04
Total	**1,827.36**	**402.73**	**7,857.95**	**10,101.36**	**15,729.22**
EIRR					**14.5%**

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

C. Sensitivity and Risk Analysis

11. Five sensitivity scenarios were tested. Their results are shown in Table 8. Even the removal of all assumed induced and/or extra traffic from the rural roads and the Menglian–Meng'a Highway components results in an EIRR of 13.9%. One scenario assumed that implementation was delayed by 2 years. In this scenario, all aspects of implementation were assumed to be extended by 2 years, with the appraisal horizon extended accordingly, but the results were still assessed from a 2015 perspective. Testing showed that this would actually improve all metrics except the payback period. This is because implementation costs would be spread further into the future, discounted values would decrease, and time-based benefits would increase due to increasing values of time.

12. These figures support the project, particularly since likely benefits from accident reductions associated with the project, among other benefits, have not been included in the economic analysis. Nor have positive impacts on ethnic minorities, women, and children been quantified. Nevertheless, care is required to ensure that substantial cost overruns do not occur.

Table 8: Sensitivity Analysis

Scenario	EIRR (%)	BCR	NPV (CNY million) at 12%	Payback Period	Switching Values
A. Base Case	14.5	4.86	706	2026	
B. Costs increase by 20%	12.6	4.05	195	2027	Costs +27%
C. Benefits decline by 20%	12.2	3.89	54	2027	Benefits -22%
D. Combination of A and B	10.5	3.24	(457)	2028	
E. No Induced or Extra Traffic	13.9	4.58	531	2026	Costs +21% Benefits -18%
F. Two Year Delay in Implementation	15.0	5.73	858	2026	Costs +37% Benefits -27%

BCR = benefit–cost ratio, EIRR = economic internal rate of return, NPV = net present value, () = negative.
Source: Asian Development Bank estimates.

D. Summary and Conclusion

13. All project components provide positive economic returns, based on the information available and the assumptions made for the economic analysis. From an economic perspective, this project should be pursued.