ECONOMIC AND FINANCIAL ANALYSIS

A. Output 1: Climate-resilient transport infrastructure improved

1. The project will support a total of 121.8 kilometers (km) of road improvement in Binh Dinh and Quang Nam provinces to build connectivity and accessibility between rural ethnic minority communities and provincial and district road networks. The project districts are located in the western part of the provinces, which have low population densities; the major economic output is acacia wood for the export chip market. Economic outputs are diversifying, and other higher-value crops (including sugarcane, cassava, durian, citrus, and fruit) are being produced closer to reliable water and transport networks. The benefits of commune- and/or district-level road subprojects include significant reductions in travel time and vehicle operating costs; these subprojects will also help connect households with markets as well as social and administrative services, including health and education centers. The social and economic connectivity benefits will be reported but in most cases not valued in the feasibility study economic analysis. For the representative road subproject the connectivity value is linked to the loss of connectivity during extreme events and flooding, in particular when employees are disconnected with the local industrial site, and local ethnic minorities living in Vinh Thanh town are prevented from accessing their lands.

2. An economic assessment was completed for a subproject in Binh Dinh province that will upgrade road PR637, comprising two sections totaling 32.4 km in Vinh Thanh district. The northern section of 30.0 km runs from Vinh Son to Dinh Binh reservoir, while the 2.4 km section is associated with Vinh Thanh town and Ta Suc industrial zone. Acacia is the predominant crop in the area north of Vinh Thanh town. Currently, transport of acacia is limited to medium- and small-sized trucks, whereas under normal road conditions payloads two to three times these are usual. The impact is increased transport cost for a high-volume, low unit-value commodity, and the increased number of trucks using PR637. The 2.4 km section has substantial passenger traffic; the high number of smaller trucks using this section is resulting in capacity constraints, with disruptions as a result of flooding.

3. In the without-project scenario the project increased traffic demand on the 2.4 km section will extend the current peak traffic loading over longer periods of the day as users adopt coping strategies. For the 30.0 km section, truck size limitations will remain and result in higher numbers of trucks with higher freight costs compared to vehicles with higher payloads. The with-project scenario enables high payloads at satisfactory speeds through 2033, after which capacity constraints may add to transport costs. For the 2.4 km section, improved road capacity and upgrading of bridges to avoid flooding will ensure free-flowing traffic at forecast demand levels throughout the economic life of the invested road, reducing the extent and cost of coping strategies.

1. Assumptions

4. The economic assessment applies 2019 constant prices, using a world price numeraire. Investment, administration and maintenance, and benefits were distinguished into tradable and non-tradable components, and a standard conversion factor (SCF) of 0.9545[1] was applied to non-tradable items; a shadow wage rate factor of 0.95 was assumed for labor cost components. Tax and interest are excluded from economic costs and benefits. The assessment period comprises the subproject implementation period plus a 20-year benefit period.

[1] The equivalent shadow wage rate factor is 1.0477.

2. Traffic Demand Forecast

5. Traffic forecasts were prepared using April 2019 traffic counts from Vinh Thanh and Ta Suc, supplemented by information collected in June 2019 for the 30.0 km section area; and (ii) an assumed 7% per year annual regional gross domestic product growth rate,[2] with an income elasticity of transport demand of 0.67.[3] The information collected in June 2019 was used to derive the without-project forecast traffic for the 30.0 km section by applying the following estimated traffic shares by vehicle classification to the 2.4 km section without-project traffic forecasts: motorcycle (20%); car (10%); small or medium bus (20%); small truck (2%); medium truck (78%) applied to the small or medium truck total; and heavy bus, heavy truck or truck trailer (0%). The with-project scenario forecast for the 30.0 km section traffic assumes (based on transport operator interviews) that medium truck traffic in the without-project scenario would consolidate into fewer heavy trucks (Table 1).

Table 1: Traffic Demand Forecast (Daily # of Vehicles)

Year	Motor-cycle	Car	Small, Medium Bus	Heavy Bus	Small, Medium Truck[a]	Heavy Truck	Truck and Trailer	Total AADT	AADT except motor-cycle	ACGR (%)
Without Project: Provincial Road 637 2.4-kilometer section										
2019	2,056	201	40	22	309	27	1	2,656	600	
2023	2,214	231	46	25	355	31	1	2,903	688	3.5
2033	2,507	365	73	40	561	49	2	3,596	1,089	4.7
2043	2,570	577	115	63	887	77	3	4,292	1,722	4.7
Without Project: Provincial Road 637 30.0-kilometer section										
2019	411	20	8	0	247	0	0	687	275	
2023	443	23	9	0	284	0	0	759	316	3.5
2033	501	36	15	0	449	0	0	1,001	500	4.7
2043	514	58	23	0	709	0	0	1,304	790	4.7
With Project: Provincial Road 637 2.4-kilometer section										
2023	2,214	231	46	25	78	132	1	2,727	512	
2033	2,507	365	73	40	123	208	2	3,317	810	4.7
2043	2,570	577	115	63	195	329	3	3,852	1,282	4.7
With Project: Provincial Road 637 30.0-kilometer section										
2023	443	23	9	0	7	101	0	583	140	
2033	501	36	15	0	11	159	0	723	221	4.7
2043	514	58	23	0	18	252	0	864	350	4.7

AADT = annual average daily traffic, ACGR = annually compounded growth rate.

[a] For the 30-kilometer (km) section acacia log carriers wait at loading points along the road section. Assuming uniform distribution of these loading points, each average truck will use 15 km of the 30 km section per trip.

Source: Transaction technical assistance consultant.

[2] The impact of coronavirus disease (COVID-19) on Viet Nam's gross domestic product (GDP) is reported to be mild; in June 2020 ADB forecast GDP growth rates of 4.1% for 2020, and 6.8% for 2021; these decreased to 2.3% for 2020 and 6.1% for 2021 in the December 2020 ADB forecast. The GDP growth rate for Binh Dinh is expected to continue to be higher than the national average—the economic drivers for export of natural resources and manufactured natural resources declined by less than 2% as of August 2020 (year on year), and the strong domestic tourism market resulted in occupancy rates being higher in 2020 than 2019. The sensitivity of the project to reductions in GDP stemming from COVID-19 is negligible: a 2% GDP growth rate reduces the EIRR from 12.5% to 12.1%.

[3] P. Goodwin, J. Dargay, and M. Hanly. 2011. Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. *Transport Reviews*. 24 (3). pp. 275–292.

3. Cost

6. The subproject costs consist of economic costs of road construction, land acquisition and resettlement;[4] periodic and routine maintenance;[5] and consulting services. These include a 10% physical contingency.

4. Benefits

7. Benefits included in the assessment are reductions in : (i) vehicle operating costs (VOCs); (ii) time; and (iii) carbon dioxide emissions.

8. **Vehicle operating costs.** VOCs were quantified using a function relating speed to the road traffic volume-to-capacity ratio.[6] For this purpose, the traffic volume is measured in traffic flow units, with the annual average traffic speed for the without-project or with-project scenarios input into a unit VOC estimating tool.[7] The VOCs by vehicle speed were estimated for two basic vehicle types—car or delivery van (small truck), and heavy truck. Unit VOCs for a more detailed vehicle classification were derived from the basic model by assigning relative weights (i) to the car VOC for small trucks and small buses; and (ii) to the heavy truck VOC for high-capacity vehicles (i.e., all buses and trucks except the small buses and delivery vans or small trucks). An example of estimated unit VOC by vehicle type is detailed in the supplementary document[8] and (i) includes (a) fuel cost per km for vehicle types using fuel consumption by speed, and fuel costs; and (b) non-fuel costs, including tires, operation and maintenance (O&M), and depreciation; but (ii) excludes driver costs that are included in the time-saving benefits.

9. The estimated VOC assumes a constant economic crude oil price of $70 per barrel. The VOC tool output is by vehicle speed and for (i) car or delivery van (small truck) and (ii) heavy truck. The vehicle classification was disaggregated by assigning relative weights to the car VOC for small trucks and small buses, and to the heavy truck VOC for high-capacity vehicles (i.e., all buses and trucks except the small buses and delivery vans or small trucks). VOC benefits contribute 22% of total benefits, with the EIRR relatively insensitive to the oil price, as demonstrated in the sensitivity analysis.[9]

10. **Time cost**. Vehicle hours traveled are used to estimate value of time per person per hour traveled, separating work and non-work time travel, with non-work counted as 0.25 of the work value of time, at an hourly economic rate after applying the SCF and SWRF of $0.33 per car passenger, $0.17 per bus passenger, and $0.68 per truck. Consolidating medium truck loads into fewer heavy trucks in the 30 km section creates with-project savings in the daily time cost of freight vehicle drivers that use a full work-time rate. The value of time costs are disaggregated for

---

[4] A total of 3.6 hectares of land is affected of which 0.04 ha is residential with a market value of VND 640,000/m^2 and 3.0ha with a market value of VND 24,000/m^2 based on the inventory of loss and market survey.

[5] Cost estimates for the annual and periodic maintenance requirements of the subproject were estimated by the engineering team.

[6] The function was estimated using the United States Federal Highway Administration definition of five road levels of service (denoted A to F), and calculates traffic speed as a fraction of design maximum speed using the ratio of traffic volume to traffic flow capacity per hour (Volume/Capacity ratio). United States Federal Highway Administration. 1999. Highway Capacity Manual. Washington, DC.

[7] B. Hamilton, H. Bailly, and P.Brinkerhoff. 1999. California Life-Cycle Benefit/Cost Analysis Model (Cal B/C): Technical Supplement to User's Guide. California.

[8] Detailed Economic Analysis: Binh Dinh Province Vin Thanh Road Subproject (accessible from the list of linked documents in Appendix 2 of the Report and Recommendation of the President).

[9] As of 1 September 2020, the oil price was $49 per barrel and is projected to reach $58 to $60 by mid-2021 (WB Commodity Market Forecast April 2020). A VOC reduction of 50% results in an EIRR of 11.2%.

work and non-work under the assumption that the time for all truck drivers is work based and valued at the daily wage rate, while the time for drivers of all other vehicles treated as non-work is valued at 0.25 of the daily wage rate.

11. **Carbon dioxide emissions**. Assessment of the carbon dioxide (CO_2) emissions for the without-project and with-project scenarios uses the VOC fuel consumption in liters as a function of vehicle speed, two vehicle types, and differentiates by gasoline and diesel fuel. It was assumed that cars operate on gasoline and other vehicles on diesel. ADB's guidelines for mobile combustion engine CO_2 emission factors (2.70 kilograms per liter for diesel fuel and 2.32 kilograms per liter for gasoline) were used to estimate the carbon emissions in kilograms.[10] Valuation of the CO_2 emissions uses the ADB social cost of CO_2 of $36.3 per ton, increased at 2% per year in constant 2016 dollars. With insufficient data, it was not possible to estimate the incremental vehicle CO_2 emissions caused by reduced traffic speed, or road users' coping strategies during project construction.[11] It is estimated that the incremental reduction in CO_2 emissions increases from nearly 700 tons in 2023 to 1,639 tons in 2043, but using ADB's valuation this represents a trivial benefit, and the value was therefore not included in the subproject economic net cash flow.

12. **Unquantified benefits.** The road improvement subproject provides additional benefits that are not quantified, including (i) improved road safety through widening of the bridge section to two lanes; (ii) reliable access to customary lands for ethnic minority communities resettled during the hydropower development program; (iii) increased road capacity and reliability to support investment into the adjacent economic industrial zone; and (iv) increased competition in the transport of goods and passengers that reduces the cost of accessing education, health and administrative services.

5. Assessment Results

13. **Project economic viability**. The subproject economic internal rate of return (EIRR) is 12.5% and the net present value at a 9% discount rate is $4.59 million, indicating the project is economically viable. This result incorporates an annual provision for increased road user costs (time and VOCs) during construction of 25% of the opening year (2023) total benefit (Table 2).

Table 2: Analysis of Subproject Economic Returns
($ million)

Year	Costs		Total					Total	Net Benefit
	Capital	Recurrent and Periodic[a]	Cost	VOC Saved	Time Cost Saved			Benefit	Stream
					Non-work	Work	Total		
2019	0.00	0.00	0.00	0.00			0.00	0.00	0.00
2020	4.80	0.00	4.80	(0.09)			(0.28)	(0.37)	(5.17)
2021	6.00	0.00	6.00	(0.09)			(0.28)	(0.37)	(6.36)
2022	1.20	0.00	1.20	(0.09)			(0.28)	(0.37)	(1.57)
2023	0.00	0.06	0.06	0.37	0.1	1.0	1.10	1.47	1.42
2024	0.00	0.06	0.06	0.39	0.1	1.03	1.13	1.52	1.47
2025	0.00	0.06	0.06	0.40	0.1	1.07	1.17	1.57	1.51

[10] ADB. 2017. *Guidelines for Estimating Greenhouse Gas Emissions of ADB Projects*. Manila.

[11] There may be benefit from a sensitivity-type analysis that addresses questions such as the following: if incremental CO_2 for each year of the construction period (2020–2023) equals 1.5 times the without-project carbon emissions for year 2023, how many years of with-project carbon savings would it take to eliminate the deficit? The answer is 10.

Year	Costs		Total					Total	Net Benefit
	Capital	Recurrent and Periodic[a]	Cost	VOC Saved	Time Cost Saved			Benefit	Stream
					Non-work	Work	Total		
2026	0.00	0.06	0.06	0.41	0.1	1.1	1.20	1.62	1.56
2027	0.00	0.06	0.06	0.43	0.1	1.14	1.24	1.67	1.61
2028	0.00	0.06	0.06	0.44	0.1	1.18	1.28	1.72	1.67
2029	0.00	0.06	0.06	0.48	0.1	1.38	1.48	1.95	1.90
2030	0.00	0.06	0.06	0.51	0.14	1.57	1.71	2.22	2.16
2031	0.00	0.80	0.80	0.55	0.17	1.80	1.97	2.52	1.72
2032	0.00	0.05	0.05	0.58	0.20	2.07	2.28	2.86	2.81
2033	0.00	0.05	0.05	0.63	0.25	2.38	2.63	3.26	3.21
2034	0.00	0.05	0.05	0.64	0.21	2.40	2.61	3.25	3.20
2035	0.00	0.05	0.05	0.65	0.17	2.43	2.60	3.25	3.20
2036	0.00	0.05	0.05	0.67	0.14	2.43	2.58	3.25	3.20
2037	0.00	0.05	0.05	0.68	0.12	2.44	2.57	3.25	3.20
2038	0.00	0.05	0.05	0.70	0.10	2.45	2.55	3.25	3.20
2039	0.00	0.05	0.05	0.73	0.10	2.57	2.67	3.40	3.35
2040	0.00	0.05	0.05	0.76	0.11	2.69	2.79	3.55	3.50
2041	0.00	0.05	0.05	0.79	0.11	2.81	2.92	3.71	3.66
2042	0.00	0.05	0.05	0.82	0.11	2.94	3.06	3.88	3.83
2043	0.00	0.05	0.05	0.85	0.12	3.08	3.20	4.05	4.00
								EIRR	**12.5%**
								NPV	**4.59**

( ) = negative, EIRR = economic internal rate of return, NVP = net present value, VOC = vehicle operating cost.
[a] One periodic maintenance episode was included, given the analysis period and planned upgrading of the road.
Source: Transaction technical assistance consultant

6. Sensitivity Analysis

14. If benefits are reduced by 20.0%, the EIRR falls to 10.1%; the benefit switching value is 27.8%. If the oil price falls to $40 per barrel, which would reduce the benefit from VOC savings, the EIRR falls from 12.5% to 12.1%, with a switching value is 156.1%. If costs increase by 20.0%, the EIRR falls to 10.7%, with a cost switching value of 42.7%. If benefits fall by 15.0% and costs simultaneously increase by 15.0% the EIRR falls to 9.4%. These sensitivity measures indicate that the subproject economic viability is robust.

Table 3: Sensitivity Analysis Indicators

Case	**EIRR** (%)	**Switching Value** (%)
Base case	12.5%	Not applicable
Benefit reduced by 20.0%	10.1%	(27.8%)
Oil price at $40 per barrel	12.1%	(156.1%)
Cost increased by 20.0%	10.7%	42.7%
Benefit reduced by 15.0% and cost increased by 15.0%	9.4%	Not applicable

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

7. Operation and Maintenance

15. No revenue generation is allowed for provincial roads, and the subproject road O&M will therefore be supported under the Provincial Road Fund, which was formally established in 2018 with a base annual funding commitment of D11 billion per year.[12] By 2024 (the first year of road operations) the fund will have increased to D14.7 billion. The subproject O&M costs associated with the road carriageway are estimated at D22.9 million per year, and costs for the two bridges at D64.88 million per year; as such the subproject annual O&M costs represents less than 0.5% of the annual Provincial Road Fund commitment. All output 1 subprojects in the province will account for less than 2% of the annual O&M budget.

B. Output 2: Climate-resilient water resource infrastructure improved

16. The feasibility of output 2 investments was tested using representative water supply networks in the An Lao district of Binh Dinh. The Binh Dinh Provincial People's Committee (PPC) has prioritized the provision of clean, reliable, and potable water for small town and rural communes within its socioeconomic development plan.[13] The project proposed a number of water supply networks in the An Lao District, including (i) a small town water supply network for around 2,000 households and (ii) rural commune water supply networks for around 200 households. The technical assistance selected one of each type as representative of the proposed water supply investments under output 2. The network designs are based on population and water demand projections for 2045.

17. The subproject seeks to ensure each network delivers reliable potable water to each household on a continuous (24-hours per day) basis.

1. An Lao Water Supply Network

18. The An Lao Small Town Water Supply Network will supply potable water to about 20,000 people via 4,250 connections by 2045 by producing around 3,500 cubic meters (m^3) of water per day to serve an estimated 85% of the population. The proposed scheme includes the following works: (i) installation of a new water treatment plant; (ii) a new intake from the irrigation canal; (iii) a booster pumping station to increase mainline pressure; (iv) a network upgrade including replacement of mainlines installed prior to 2014 with new diameter and pressure-rated mainlines and submains that will be extended to provide coverage to three more communes; (v) provision of household connections, including water meters; and (vi) installation of additional mainline capacity to support the south An Hoa commune extension to future-proof the hydraulic performance of this southern service area. The expected investment is $1.23 million.

2. An Trung Water Supply Network

19. The proposed scheme will produce up to 150 m^3 of water per day and provide reliable 24-hour per day water to Dong Mit village 6, Dong Nong 5, and Village 5 consisting of a total of 220 households with an average household size of 3.8 persons. The scheme is designed to serve a projected 2045 population of 1,125 through 454 household connections, out of a total commune population of 1,157.

[12] Binh Dinh PPC March 9, 2018: ref 763/QD-UBND: Approval of Price Norms, public service costs for management and regular maintenance of Provincial Roads (2018-2020)

[13] Government of Viet Nam. 2009. *Decision No. 54/2009/QD-TTG dated 14 April 2009 approving the socio-economic development master plan of Binh Dinh province through 2020.* Ha Noi

20. The proposed scheme sources water from the existing offtake from the Ra Ngam stream and will construct a replacement sand filter system close to the existing headworks; a single mainline will be installed within the existing road reserve and then split into two distribution mainlines: one to the east to supply Village 5 and one to the west supplying Dong Mit Village 6. All households will be connected into the distribution mainlines. The proposed investment in An Trung is $120,000.

3. Assumptions

21. The domestic price numeraire is applied to the subproject with a shadow exchange rate of 1.047 imputed from 2017 data,[14] with the value added tax element of 10% removed. To maximize the early revenue streams and the schemes' sustainability, the project will provide connections to each household during construction. All costs and values are presented in constant 2019 terms.

22. The assessment estimates benefits relating to (i) health, (ii) time savings, and (iii) water purchase savings. The economic value of incremental water is valued at the average financial tariff, and the value of non-incremental water at 50% of the current tariff applied to the first consumption step for domestic consumers (i.e., D1,050 per m^3 in An Lao and D800 per m^3 in An Trung). Non-revenue water is valued at 25% of the value of incremental water (i.e., D2,104 per m^3 in An Lao and D1,474 per m^3 in An Trung commune).

23. Health benefits are derived from the socioeconomic survey data and a randomized 2014 survey.[15] These indicate a diarrhea incidence of 0.28 episodes per person year, but this increases with risk factors such as pond water sources (2.3 episodes per person year), river water (2.4 episodes per person year), and rainwater (5.4 episodes per person year). The attributable fractions for exposure (defined as the cases that would be eliminated if the exposure was eliminated) are 27% for river water, 14% for pond water, and 77% for rain water. Key assumptions related to health benefits are: (i) in An Lao an incidence rate of 50% of 0.28 because there are fewer farming heads of households, and in An Trung the rate of 0.28 from the study is applied; (ii) the duration of each episode is 2 days; (iii) the value of time lost is equal to 25% of the 2019 casual daily wage rate, or D35,000; and (iv) 1 in 10 episodes requires medication, at a cost in 2019 of D140,000. No costs for medical consultation were included.

24. The value of time saved is derived from the household survey and is valued at 25% of the 2019 daily casual wage rate of D35,000. The time savings were estimated per month of the year reflecting the increased proportion of people involved in collecting water during the dry season (64%, compared with 13% outside the dry season) based on an average time of 17 minutes to collect water in An Lao. In An Trung, up to 71% collected water in the dry season, taking an average of 14 minutes per trip.

25. Savings from purchasing water were identified in the social surveys and it is assumed that 7% to 8% of households purchase water, at a cost of D30,000–D720,00 per month. The assessment assumes purchases were only made for 6 months per year.

26. The financial performance of the networks is determined by the required tariff. Current tariff structures are locally applied and inadequate to maintain the infrastructure (An Lao town's infrastructure has rapidly degraded since being upgraded in 2013). The PPC has agreed and

[14] Equivalent to a SCF 0.9545.

[15] P. Pham-Duc et. al. 2014. Diarrhoeal Diseases Among Adult Population in an Agricultural Community Hanam Province, Vietnam with High Wastewater and Excreta Re-use. *BMC Public Health.* 14 (978).

enacted a transfer of scheme management and operation to the Provincial Water Supply and Sanitation Unit (WSSU) of Department of Agriculture and Rural Development. The WSSU successfully operates seven rural water supply schemes, although the assets remain outside their balance sheet, and are held by the PPC. The WSSU applies a PPC-approved tariff while requesting a 100% cost-recovery tariff that includes both operational costs and capital depreciation. The PPC discounts their requests and offsets this through the provision of capital grants to maintain and extend the assets.

27. Tariff models were prepared based on the cost structure of Phu Cat Water Supply Scheme, which is of a similar scale and technology to the proposed An Lao small town network. The average tariff calculated for the two networks is D8,676 per m^3 for An Lao and D6,076 per m^3 for An Trung. Based on the social survey data, the cost of water to the poorest households (by household size) as a proportion of household income was 2.2% for An Lao and 1.6% for An Trung based on a tariff structured on 10 m^3. Even for the larger 20 m^3 tariff step per month, the proportion of household income was 2.7% and 3.3% for the poorest households. In conclusion, the tariff required is affordable across all income groups and should be a prerequisite for any ADB investment.

28. The financial viability of the schemes was estimated using the proposed tariff and water demand data for both networks. The financial internal rate of return (FIRR) was 4.70% while the net present value was D23,737 when discounted at the weighted average cost of capital based on real interest rates of 0.94%. The FIRR for An Lao was 4.71%, while the FIRR for An Trung was 3.10%.

29. The economic viability of the schemes was tested using the ADB with-project scenario less without project scenario economic assessment and using the assumptions for costs and benefits described above.[16] The resultant EIRR was 12.3% for both networks, with An Lao having an EIRR of 12.7% and An Trung an EIRR of 7.1%, which rose to 8.4% if the cost of water meters is removed and each connected household simply pays a per capita rate.

30. A quantified risk assessment was undertaken with probability functions developed for (i) capital cost; (ii) O&M costs; and (iii) volume sold using WSSU engineers and staff. For An Lao, there is a 25% chance that the average tariff would be D9,130 rather than D8,676 per m^3. At a tariff of D9,130, the cost of water will still be less than 5% of the income of the poorest households; as such, the likelihood that this will be unaffordable is considered low. For An Trung, there is a 25% chance that the average tariff would exceed D6,266 per $m^{3,}$ which is also well within the upper limit of household affordability.

[16] The benefits are based on the financial tariff, which represents the economic value of incremental water, non-incremental water, and non-technical water losses. In addition to the tariff, estimates for health benefits, time savings and avoided costs for purchase of water are included for health impact of access to rural potable water supply, while data from the transaction technical assistance socio-economic survey was used to identify time savings and the costs saved from avoided water purchases.