VIET NAM: BASIC INFRASTRUCTURE FOR INCLUSIVE GROWTH IN THE NORTH CENTRAL PROVINCES SECTOR PROJECT

DETAILED ECONOMIC AND FINANCIAL ANALYSIS

- ROADS

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A. Introduction

1. The road subproject will upgrade provincial and district road sections in the four north central provinces (NCPs) of Ha Tinh, Quang Binh, Nghe An, and Quang Tri. At completion, these road sections will be owned and managed by the respective provincial governments. Feasibility studies were carried out for representative subprojects in Quang Binh, Nghe Ahn, and Quang Tri. The Quang Binh subproject is further divided into three sections.

2. Due to provincial government's budget constraint for major works on roads, currently only limited maintenance is carried out. The economic and financial analysis (EFA) assumes the status quo will prevail in the without-project scenario, hastening road deterioration and resulting in higher road user costs. With the project, the roads will be upgraded with a double bituminous surface treatment and maintained adequately.[1] The EFA captures the differences in road user costs between the two scenarios.

B. Traffic Forecast

3. **Traffic categorization**. Three categories of traffic are distinguished in the analysis: normal, generated, and diverted. Both normal and generated traffic are sourced within subproject areas and are demanded by local road users. Normal traffic is driven by income growth in subproject areas and will change with or without the project. Road conditions improvement will simulate more local traffic as travelling becomes more convenient. Additional traffic is thus generated by the subproject and occurs only in the with-project scenario. Lastly, diverted traffic is traffic sourced from outside but are rerouted to the improved subproject roads in response to lower road user costs, vis-à-vis other existing routes. The vehicles are from other parts of the road network. The sources and determinant of each traffic type are summarized in Table 1. Of the three categories, only generated traffic is incremental.

Table 1: Traffic Type

Traffic type	Source of demand	Determinant	Incremental
Normal	Local users	Income growth	No
Generated	Local users	Reduced road user costs	Yes
Diverted	Outside users	Reduced distance; Reduce road user costs	No

4. **Vehicle composition**. The analysis considers different vehicles that can be grouped into two broad categories, passenger and freights vehicles. The former consists of motorcycles, personal cars, pick-ups, and buses of various size, while the latter consists of delivery vans and trucks of different sizes. The specification of vehicle composition is necessary since different vehicle types entail different road user costs. Hence, the road cost savings from the road subprojects would also differ.

5. **Normal traffic** forecasts are based on (i) October 2016 traffic counts for different vehicles types; (ii) expected growth in provincial gross domestic product (GDP); (iii) income elasticities of traffic demand; and (iv) analyses of regional trade and tourism patterns. Project provinces GDP

[1] Double bituminous surface treatment has a lower cost-to-output ratio than the alternatives of triple bituminous surface treatment and asphalt cement pavement.

grew at 6.5% to 8.1% in 2015 and are assumed to grow at 7.9% to 9.2% between 2017 and 2040. An income elasticity of 0.88 was applied to provincial GDP growth rates to estimate the baseline traffic growth rates.[2] The traffic growth estimates are presented in Table 2.

Table 2: Subproject Provinces Projected GDP Growth and Traffic Growth
(%)

	2015	2020	2025	2030	2035
Viet Nam GDP growth[a]	6.7	6.1	5.5	5.0	5.0
Quang Binh[a]					
PGDP growth (A)	8.1	8.9	9.2	8.9	8.7
Income elasticity (B)[b]	0.88	0.88	0.88	0.88	0.88
Baseline growth rate (B_{QB} = A*B)	7.1	7.9	8.1	7.8	7.7
Nghe An[a]					
PGDP growth (A)	7.0	7.8	8.1	8.0	7.9
Income elasticity (B)[b]	0.88	0.88	0.88	0.88	0.88
Baseline growth rate (B_{NA} = A*B)	6.2	6.9	7.1	7.0	7.0
Quang Tri[a]					
PGDP growth (A)	6.9	7.6	7.9	8.0	8.2
Income elasticity (B)[b]	0.88	0.88	0.88	0.88	0.88
Baseline growth rate (B_{QT} = A*B)	6.1	6.7	6.9	7.1	7.2

GDP = gross domestic product; PGDP = provincial gross domestic product.
[a] Source: for Viet Nam, data.worldbank.org accessed 12 October 2016 for 2015; for the provinces, the Statistical Yearbook 2016 of each province.
[b] Source: P. Goodwin, J. Dargay, and M. Hanly. 2004. Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. Transport Reviews, 24:3, pp. 275–292.

6. The above baseline traffic growth rates were adjusted for specific vehicle types. For passenger traffic, travel by motorcycle is an inferior good. As income rises, the growth rate of motorcycle traffic can be expected to decline and eventually turn negative, while growth of personal vehicle increases. To account for this, the growth rates for motorcycle and personal car traffic were derived from multiplying the baseline growth rate with adjustment factors (Table 3).

Table 3: Motorcycle and Personal Car Traffic Growth Adjustment

Item	2015	2020	2025	2030	2035
Adjustment factors					
Motorcycle (A_m)	0.50	0.33	0.25	0.10	-0.05
Personal car (A_{pc})	0.80	0.90	1.00	1.05	1.10
Quang Binh Traffic growth rate (%)					
Baseline (B_{QB})	7.10	7.90	8.10	7.80	7.60
Motorcycle ($M_{QB} = B_{QB}*A_m$)	3.55	2.61	2.03	0.78	-0.38
Personal car ($P_{QB} = B_{QB}*A_{pc}$)	5.68	7.11	8.10	8.19	8.36
Nghe An Traffic growth rate (%)					
Baseline (B_{NA})	6.20	6.80	7.20	7.10	6.90
Motorcycle ($M_{NA} = B_{NA}*A_m$)	3.10	2.24	1.80	0.71	-0.35
Personal car ($P_{NA} = B_{NA}*A_{pc}$)	4.96	6.12	7.20	7.46	7.59
Quang Tri Traffic growth rate (%)					
Baseline (B_{QT})	6.10	6.70	6.90	7.10	7.20
Motorcycle ($M_{QT} = B_{QT}*A_m$)	3.05	2.21	1.73	0.71	-0.36
Personal car ($P_{QT} = B_{QT}*A_{pc}$)	4.88	6.03	6.90	7.46	7.92

Source: PPTA consultant.

7. Secondly, with regards to freight traffic, there will be changes in the composition of vehicle types. Freight traffic is currently dominated by smaller vehicles which cope better with poor road conditions. However, with the project, freight traffic will migrate to heavier, higher-capacity

[2] The income elasticity is taken from P. Goodwin, J. Dargay, and M. Hanly. 2004. Elasticity of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. *Transport Reviews.* 24 (3).

vehicles to avail of economies of scale. The change in vehicle composition was computed by first estimating the implied total freight tonnages based on the 2016 traffic counts and baseline traffic growth rates for the freight vehicles. Secondly, the total freight tonnages were reassigned to heavier vehicles. The traffic counts for different freight vehicles were then computed based on the freight tonnages. Table 4 summarizes the average load of different freight vehicles, and their share of freight tonnage in the with-project scenario.

Table 4: Freight Traffic Composition Redistribution

	Delivery Van	Small Truck	Medium Truck	Heavy Truck	Trailer
Quang Binh					
Average load (tons)	1.5	3.5	7.5	12.5	20.0
With-project distribution (%)	5.0	7.0	30.0	55.0	3.0
Nghe An					
Average load (tons)	1.5	3.5	7.5	12.5	20.0
With-project distribution (%)	10.0	7.0	30.0	45.0	8.0
Quang Tri					
Average load (tons)	1.5	3.5	7.5	12.5	20.0
With-project distribution (%)	5.0	7.0	20.0	65.0	3.0

Source: PPTA consultant.

8. **Generated traffic** is derived as 20 to 50% of normal traffic, depending on vehicle types. (Table 5).

Table 5: Assumed Generated Traffic Factors

	Passenger traffic						Freight traffic			
	Motor-cycle	Personal car	Pickup	Small Bus	Medium Bus	Large Bus	Delivery Van & Small Truck	Medium Truck	Heavy Truck	Truck & Trailer
Quang Binh R1	20%	20%	20%	20%	20%	20%	0%	0%	0%	0%
Quang Binh R2	50%	50%	50%	50%	50%	50%	35%	35%	25%	25%
Quang Binh R3	50%	50%	50%	50%	50%	50%	35%	35%	25%	25%
Nghe An	30%	30%	30%	30%	30%	30%	30%	30%	0%	0%
Quang Tri	50%	50%	50%	50%	50%	50%	0%	0%	0%	0%

Source: PPTA consultant.

9. Table 6 presents the forecasts normal and generated traffic in the without-project and with-project scenarios. Note that while generated traffic is not presented separately to save space, it can be deferred from taking the difference between the without-project and with-project traffic count.

Table 6: Normal and Generated Traffic Forecasts (Daily Vehicles) [a,b]

	Passenger traffic						Freight traffic			
	Motor-cycle	Personal Car	Pickup	Small Bus	Medium Bus	Large Bus	Delivery Van & Small Truck	Medium Truck	Heavy Truck	Truck & Trailer
<u>Without Project</u>										
Quang Binh (3 Sections)										
2016 [a]	2,507.7	567.7	0.0	48.0	7.0	0.0	261.3	15.7	4.7	0.0
2020	2,815.7	772.7	0.0	64.9	9.5	0.0	353.6	21.2	5.9	0.0
2030	3,330.7	1,609.1	0.0	123.1	17.5	0.0	686.5	39.1	8.9	0.0
2040	3,243.1	3,320.2	0.0	207.6	25.1	0.0	1,226.7	56.2	11.3	0.0
Nghe An: DR349 Subproject										
2016 [a]	940.1	31.3	0.0	1.7	0.5	0.0	70.0	20.0	5.3	0.0
2020	1,040.0	41.0	0.0	2.2	0.7	0.0	88.6	25.3	6.7	0.0
2030	1,197.1	90.9	0.0	4.3	1.3	0.0	147.5	42.2	11.2	0.0
2040	1,150.9	208.3	0.0	8.4	2.5	0.0	240.3	68.7	18.3	0.0

	Passenger traffic						Freight traffic			
	Motor-cycle	Personal Car	Pickup	Small Bus	Medium Bus	Large Bus	Delivery Van & Small Truck	Medium Truck	Heavy Truck	Truck & Trailer
Quang Tri Gio Linh–Cam Lo Inter-District Road Subproject										
2016 [a]	456.0	56.7	0.0	3.0	0.0	0.0	63.0	0.0	0.0	0.0
2020	503.6	73.9	0.0	3.9	0.0	0.0	81.7	0.0	0.0	0.0
2030	562.1	138.3	0.0	6.7	0.0	0.0	140.5	0.0	0.0	0.0
2040	539.5	328.3	0.0	13.5	0.0	0.0	282.6	0.0	0.0	0.0
With Project [b]										
Quang Binh (3 Sections)										
2016 [a]	2,507.7	567.7	0.0	48.0	7.0	0.0	261.3	15.7	4.7	0.0
2020	2,815.7	772.7	0.0	64.9	9.5	0.0	353.6	21.2	5.9	0.0
2030	4,664.1	2,298.2	0.0	177.6	26.2	0.0	633.4	76.6	37.3	0.9
2040	4,525.1	4,696.3	0.0	296.6	37.6	0.0	1,042.2	128.7	72.3	2.0
Nghe An: DR349 Subproject										
2016 [a]	940.1	31.3	0.0	1.7	0.5	0.0	70.0	20.0	5.3	0.0
2020	1,040.0	41.0	0.0	2.2	0.7	0.0	88.6	25.3	6.7	0.0
2030	1,556.3	118.2	0.0	5.6	1.7	0.0	139.5	42.8	31.3	20.9
2040	1,496.2	270.8	0.0	11.0	3.3	0.0	227.2	69.8	45.2	24.7
Quang Tri Gio Linh–Cam Lo Inter-District Road Subproject										
2016 [a]	456.0	56.7	0.0	3.0	0.0	0.0	63.0	0.0	0.0	0.0
2020	503.6	73.9	0.0	3.9	0.0	0.0	81.7	0.0	0.0	0.0
2030	843.2	207.5	0.0	10.0	0.0	0.0	39.2	19.6	38.2	1.1
2040	809.2	492.4	0.0	20.2	0.0	0.0	78.8	39.4	76.9	2.2

[a] 2016 traffic count was taken on the subproject roads in October 2016. For motorcycles, only 50% of the actual count is included to adjust for local (inter-neighborhood) traffic.
[b] With-project scenario includes both normal and generated traffic. Diverted traffic is computed separately.
Source: PPTA consultant.

10. **Diverted passenger traffic in Quang Binh**. Diverted traffic was identified in all three subproject roads. In Quang Binh, one section (R1 Bao Ninh-Hai Ninh) offers a shorter distance to a new FLC golf and tourism resort, scheduled for completion in 2025.

11. Traffic counts of Quang Binh beach roads R1 Bao Ninh-Hai Ninh were taken at an extreme low-season point in December 2016. For the estimate of baseline average daily traffic, the counts were multiplied by a seasonality factor (average annual daily visitor nights divided by the December average).

Table 7: Quang Binh Nhat Le Beach Visitor Nights

2016	Visitor Nights
January	3,300
February	1,540
March	7,500
April	270,000
May	243,000
June	229,500
July	161,200
August	135,000
September	75,000
October	6,000
November	2,570
December	1,300
Annual total	**1,135,910**

Source: Quang Binh Department of Culture, Sports and Tourism.

12. The analysis assumes that 15% of the FLC resort guests and 20% of the FLC resort employees will be diverted to the subproject road. Of the expected 5,250 daily trips for guests and

4,589 daily trips for employees (Table 8, Column E), 788 guest trips and 918 employee trips will be diverted to the subproject road (Column G).

Table 8: Quang Binh Subproject R1 Bao Ninh-Ha Ninh Diverted Passenger Trips[a]

	Existing passenger traffic						Diverted passenger traffic	
	Units (A)	Occupancy (B)	Guest/unit (C)	Person/day (D = A*B*C)	Purpose	Person trip/day (E = D*2)	% Diverted (F)	Person trips/day (G = E*F)
Resort villa [b]	1,000 villas	50%	4.50	2,250	holiday	4,500	15%	675
Resort room [b]	600 rooms	50%	1.25	375	holiday	750	15%	113
Resort employees [c]	5,000 staff			2,295	work	4,589	20%	918

[a] Trips assumed to start from 2025, after the FLC resort completion date.
[b] Trips between FLC and Dong Hoi.
[c] 50% of employee live in Dong Hoi.
Source: PPTA consultant.

13. Diverted traffic is deferred from the diverted passenger trips, for each vehicle types. At completion of the FLC resort in 2025, about 124 motor-cycles, 58 personal cars, and 112 small buses will be diverted to the subproject road (Table 9, Row C_3). Given the subproject road will reduce travel distance by 10.1 km per vehicle per trip, the total vehicle kilometer (vkm) saving of 2,958 vkm per day (Table 9, Row C_4). Note that the vkm savings will not materialize until the FLC golf and tourism resort construction completes in 2025

Table 9: Quang Binh Subproject R1 Bao Ninh-Ha Ninh Diverted Passenger Traffic[a]

	Diverted passenger traffic					
	Motor-cycle	Personal car	Pickup	Small bus	Medium Bus	Large Bus
A. Composition of diverted passenger traffic						
Resort guests (A_1)	2%	15%	0%	83%	0%	0%
Resort employee (A_2)	15%	3%	0%	82%	0%	0%
Passengers per vehicle (A_3)	1.25	2.5	0.0	12.5	0.0	0.0
B. Person trip/day						
Resort guests (B_1 = 788 trips/day*A_1)	16	118	0	646	0	0
Resort employees (B_2 = 918 trips/day*A_2)	138	28	0	753	0	0
C. Daily diverted passenger traffic						
Resort guests ($C_1 = B_1/A_3$)	13	47	0	52	0	0
Resort employees ($C_2 = B_2/A_3$)	110	11	0	60	0	0
Total daily diverted freight traffic ($C_3 = C_1+C_2$)	123	58	0	112	0	0
Vehicle km saved ($C_4 = C_3$*10.1 vkm/trip)	1,240	588	0	1,130	0	0

km = kilometer, vkm = vehicle kilometer.
[a] Trips assumed to start from 2025, after the FLC resort completion date.
Source: PPTA consultant.

14. **Diverted freight traffic in Nghe An**. In the without-project scenarios, freight traffic utilizes the route NH7-NH15 to carry forestry and maize feed to processing and diary plants in Nghia Dan district. The improved subproject road will divert a share of the freight traffic, connecting them to a provincial road in Quy Hop district and NH48 and avoiding a 100 km road distance.

15. Normal freight traffic was estimated based on freight tonnages, which in turn were estimated based on data on planned capacity development,[3] forecasted output and required input of producers of medium-density fiberboard (MDF), laminated boards and dairy products. Other

[3] Nghe An Province Department of Planning and Investment.

relevant parameters are as follows: (i) 1.8 cubic meter (m^3) of round wood to produce 1 m^3 of MDF[4]; (ii) 1.7 m^3 of round wood to produce 1 m^3 of laminated board; (iii) 30 m^3 of round wood weigh 20 tons; (iv) 1 kilogram of maize feed to produce 4 liters of milk output per head of dairy cattle daily.[5]

16. Table 10 presents the forecasts for MDF, laminated board, and dairy production. As stated, based on the outputs, the required wood and maize feed inputs were estimated. Based on the inputs, the volume of freight traffic was estimated. The analysis assumes that 30% of the round wood and 10% of the maize feed ingredient are shipped via the subproject road. At subproject completion in 2020, about 15.5 freight vehicle will be diverted to the subproject road (Table 10, Row C_3). Given the subproject road will reduce travel distance by 100 km per vehicle per trip, the total vkm saving of 1,550 vkm per day (Table 10, Row C_4).

Table 10: Nghe An Subproject Diverted Freight Traffic

Item	2016	2020	2025	2030	2035	2040
A1. MDF round wood (m^3)						
Processor's planned output (A_{11})	39,000	130,000	200,000	300,000	360,000	400,000
Required round wood input ($A_{12} = A_{11}$*1.8)[a]	70,200	234,000	360,000	540,000	648,000	720,000
Round wood diverted freight ($A_{13} = A_{12}$*30%)	n.a	70,200	108,000	162,000	194,400	216,000
A2. Laminate round wood (m3)						
Processor's planned output (A_{21})	3,600	12,000	24,000	30,000	32,000	40,000
Required round wood input ($A_{22} = A_{21}$*1.7)[b]	6,120	20,400	40,800	51,000	54,400	68,000
Round wood diverted freight ($A_{23}=A_{22}$*30%)	n.a	6,120	12,240	15,300	16,320	20,400
A3. Milk production maize feed ingredient (ton)						
Processor's planned milk output (A_{31})	180,000	240,000	320,000	360,000	400,000	400,000
Required maize feed input (A_{32} = A31/4)[c]	45,000	60,000	80,000	90,000	100,000	100,000
Maize feed diverted freight ($A_{33} = A_{32}$*10%)	n.a	6,000	8,000	9,000	10,000	10,000
B. Diverted freight						
Round wood (annual m3) ($B_1 = A_{13}+A_{23}$)	n.a	76,320	120,240	177,300	210,720	236,400
Maize feed ingredient ($B_2 = A_{33}$)	n.a	6,000	8,000	9,000	10,000	10,000
C. Daily diverted freight traffic[e]						
Round wood (round trip, $C_1 = B_1/30/365*2$)	n.a	13.9	22.0	32.4	38.5	43.2
Maize feed ingredient (round trip, $C_2 = B_2/20/365*2$)	n.a	1.6	2.2	2.5	2.7	2.7
Total daily diverted freight traffic ($C_3 = C_1+C_2$)	n.a	15.5	24.2	34.9	41.2	45.9
Vehicle km saved ($C_4 = C_3$*100vkm/trip)	n.a	1,550	2,420	3,490	4,120	4,590

MDF = medium-density fiberboard, km = kilometer, m^3 = cubic meter, n.a. = not applicable, vkm = vehicle kilometer.
[a] 1.8 m^3 of round wood is required to produce 1 m^3 of MDF output.
[b] 1.7 m^3 of round wood is required to produce 1 m^3 of laminated board output.
[c] 1 kilogram of maize feed to produce 4 liter of milk output.
[d] 30m^3 of round wood weight 20 tons.
[e] Each freight shipment gives rise to two trips.
Source: PPTA consultant.

17. **Diverted freight traffic in Quang Tri**. In 2016, the national government approved a master plan for construction of Southeast Quang Tri Economic Zone. The master plan investment will increase provincial production capacity and stimulate trade and travel. Increasing traffic will constrain the capacity of two existing northeast-southwest routes, NH9-NH15 and NH9-NH1, to the Gio Linh district which is near to the Economic Zone 3. Starting from 2025, the improved Quang Tri subproject road is expected to share the traffic burden of the two routes.

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[4] Source for MDF and laminate production: http://w3.unece.org/PXWeb2015/pxweb/en/STAT/STAT__26-TMSTAT1__005-TM15Others, accessed November 2016.
[5] UK Agriculture and Horticulture Development Board (AHDB) https://dairy.ahdb.org.uk/technical-information/feeding/common-ration-ingredients/#.WHR_W1xW74w ,accessed 10 January 2017.

C. Analysis Methodology

18. The EFA follows ADB Guidelines for the Economic Analysis of Projects.[6] The major assumptions include the following:

(i) The analysis is for 25 years. The implementation period is 3 years for the road subprojects, and 5 years for the water subprojects.
(ii) The analysis uses the world price ($) numeraire. The exchange rate is VND 22,350 to $1. All prices are expressed in the 2017 price level.
(iii) Stakeholder benefits, such as vehicle operating costs, time costs, costs of medications, and bottled water, were collected in VND and converted to $.
(iv) To convert the items into economic values, taxes and subsidies are first deducted from the gross financial values. Conversion factors are then applied on the local (non-tradable), foreign (tradable), and unskilled labor components of each item.
(v) A standard conversion factor (SCF) of 0.95 is applied to all local components, including non-tradables, unskilled labor, and project benefits. For unskilled labor and value of time for beneficiaries, another adjustment is required using a shadow wage rate factor (SWRF) of 0.90.
(vi) The economic discount rate is 9%.

D. Project Costs

19. Project costs consist of road construction, engineering and construction supervision consulting services, a 10% physical contingency, and periodic (in 2031 and 2036) and routine maintenance. The physical assets have a 25-year economic life.

20. The economic and financial values of any item will differ when a tax is imposed on it, or due to exchange rate distortion arising from trade taxes or subsidies and other non-tariff barriers to trade. To conduct economic cost-benefit analysis, all investment costs must be converted from financial to economic values by netting out taxes and applying appropriate conversion factors on the tradable and non-tradable components of each item. Table 11 presents the project costs in financial and economic values, which are $27.0 million and $23.8 million, respectively.

Table 11: Road Subproject Capital Costs

	Financial Cost	Taxes	Cost net of tax	Composition		Economic Cost[a]		
				non-tradable	tradable	non-tradable	tradable	Total
	($ million)	(%)	($ million)	(%)	(%)	($ million)	($ million)	($ million)
Quang Binh R1 (10.7km)	3.75	10%	3.41	60%	40%	1.94	1.36	3.31
Quang Binh R2 (3.2km)	2.84	10%	2.58	60%	40%	1.47	1.03	2.50
Quang Binh R3 (3.7km)	0.94	10%	0.85	60%	40%	0.49	0.34	0.83
Nghe An (8.0km)	5.84	10%	5.31	60%	40%	3.03	2.12	5.15
Quang Tri (23.3 km)	13.67	10%	12.42	60%	40%	7.08	4.97	12.05
Total	**27.03**	**10%**	**24.57**	**60%**	**40%**	**14.01**	**9.83**	**23.84**

[a] Derived from financial values by applying a standard conversion factor (SCF) of 0.95 on non-tradable component.
Source: PPTA consultant.

21. Maintenance requirement is based on an estimate of $2,500 per km for recurrent maintenance, and $5,000 per km for periodic major maintenance, which is expected to be in 2031 and 2037. The recurrent and periodic maintenance costs for the subprojects are presented in Table 12.

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

Table 12: Road Subproject Maintenance Costs

	Financial Cost ($/km)	Road length (km)	Financial Cost ($)	CF	Economic Cost ($)
Quang Binh R1 (10.7km)					
Recurrent maintenance – annual	2,500	10.65	26,625	0.95	25,294
Periodic maintenance - year 2031 & 2037	5,000	10.65	53,250	1.00	53,250
Quang Binh R2 (3.2km)					
Recurrent maintenance – annual	2,500	3.20	8,000	0.95	7,600
Periodic maintenance - year 2031 & 2037	5,000	3.20	16,000	1.00	16,000
Quang Binh R3 (3.7km)					
Recurrent maintenance – annual	2,500	3.70	9,250	0.95	8,788
Periodic maintenance - year 2031 & 2037	5,000	3.70	18,500	1.00	18,500
Nghe An (8.0km)					
Recurrent maintenance – annual	2,500	8.00	20,000	0.95	19,000
Periodic maintenance - year 2031 & 2037	5,000	8.00	40,000	1.00	40,000
Quang Tri (23.3 km)					
Recurrent maintenance – annual	2,500	23.30	58,250	0.95	55,338
Periodic maintenance - year 2031 & 2037	5,000	23.30	116,500	1.00	116,500

CF = conversion factor, km = kilometer.
Source: PPTA consultant.

E. Project Benefits

22. **Overview**. Road user cost consists of vehicle operating cost (VOC) and travel time cost (TTC) which vary by vehicles type and by road conditions. Road conditions will improve due to the project, leading to reduction in VOC and TTC. Road users under the normal traffic category is already travelling with or without the project. Since normal traffic is non-incremental, the entirety of the cost savings is taken to be the economic benefits for normal traffic.

23. Without the project, travel cost is too high for some potential users with a lower willingness to incur the travel cost. These potential users will start travelling when road conditions improve, leading to additional, generated traffic. Therefore, generated traffic is incremental. Without the project, travel cost is too high for users of this category, with a lower willingness to incur the travel cost. They still gain from road use, but the magnitude of gain is less than existing road users of the normal category who attach a higher value to road use. The analysis takes half (50%) of the normal traffic's cost reduction as the economic benefit for generated traffic.

24. Road users under the diverted traffic category are already travelling on alternate routes. However, the subproject roads offer bypasses that shorten travel distance, diverting existing road users to the subproject roads. Since diverted traffic is non-incremental, the entirety of the cost savings is taken to be the economic benefits for diverted traffic.

25. In addition to VOC and TTC savings that accrue directly to road users, the analysis considered two economic externalities: carbon emission and road accidents. With shorter travel distance, diverted traffic will emit less emission and cause less accidents. However, this is offset by an increase in emission and accidents due to additional, generated traffic. The analysis captured the *net* effect and monetarized the impact accordingly. Whether these externalities enter as net project economic benefits or net project economic costs depends on whether the project will lead to an overall reduction in distance travelled (effect of diverted traffic dominates) or an overall increase in distance travelled (effect of generated traffic dominated).

26. Table 13 summarizes the project's benefits (and costs) associated with each traffic category.

Table 13. Traffic Category and Associated Benefits and Costs

Traffic type	Associated Benefits	Associated Costs
Normal	- VOC and TTC savings	
Generated	- Road user benefit (computed by multiplying the vkm of generated traffic by 50% of VOC and TTC savings per km).	- Additional carbon emission and accidents
Diverted	- VOC and TTC savings - Carbon emission and accidents reduction	

km = kilometer, TTC = travel time cost, vkm = vehicle kilometer, VOC = vehicle operating cost.

27. **Normal traffic cost savings**. Both VOC and TTC functions of the subproject roads' International Roughness Index (IRI). Table 12 presents the estimated IRI values in the without- and with-project scenario. Currently, the IRI in the subproject areas range from 14.6 to 17.0, but will continue to deteriorate at a rate of 1.2 unit per year until the maximum IRI is reached. In the with-project scenario, the IRI will reset to 2.0 initially. With proper road maintenance, the IRI will deteriorate at a rate of 0.8 unit per year and is capped at 10.0. After periodic maintenance in 2031 and 2036, the IRI will be reset to 2.0 and 3.0.

Table 14: Subproject IRIs in With-Project and Without-Project Scenario
(IRI unit)

	QB R1		QB R2		QB R3		NA		QT	
	WO	**W**	**WO**	**W**	**WO**	**W**	**WO**	**W**	**WO**	**W**
2021 IRI	13.8	2.0	17.0	2.0	13.6	2.0	17.0	2.0	17.5	2.0
IRI annual deterioration rate	1.2	0.8	1.2.0	0.8	1.2	0.8	1.2	0.8	1.2	0.8
Maximum IRI	17.0	10	17.0	10.0	17.0	10.0	18.0	10.0	18.0	10.0

IRI = International Roughness Index, NA = Nghe An, QB = Quang Bing, QT = Quang Tri, W = with-project scenario, WO = without-project scenario.
Source: PPTA consultants.

28. VOC and TTC were estimated for each vehicle type. For the without-project scenarios, data on IRIs less than 15 units, and the associated vehicle operating cost and time cost are collected from two standard Highway Development and Maintenance Management System (HDM-4) reports: *Pavement Condition Summary* for the IRI data series and, for the unit VOC and time cost data series, Motorized Traffic Road User Cost Components per 1000 Vehicle Kilometers.[7] For high IRI values of 16-20, Viet Nam sourced data were not readily available. Hence sources from a neighboring country (Laos) with similar terrain were used.[8] For the with-project scenario, data were sourced from 2016 HDM-4 reports for a road project in Viet Nam.[9] The mathematical relationship of VOC or TTC to IRI is as follows:

$$VOC = Base_{VOC} * E_{VOC}^{IRI} \quad (1)$$

$$TTC = Base_{TTC} * E_{TTC}^{IRI} \quad (2)$$

where *Base* denotes the constant or minimum VOC or TTC; *E* denotes the power term; and the exponent term *IRI* denotes international roughness index. These parameters are presented in

[7] The vehicle operating cost and time costs for different vehicle types are further decomposed into subcomponents such as fuel, lubricant, tires, spare parts, maintenance, time cost of crew and passengers.
[8] ADB.2015. Project Number: 47085-002. Lao People's Democratic Republic: Road Sector Governance and Maintenance Project.
[9] ADB. 2016. Project Number: 48189-002 Socialist Republic of Viet Nam: Support to Border Areas Development Project.

Table 15. Note that the parameters were first collected in financial terms but are converted to economic terms using appropriate conversion factors.

Table 15: Road User Cost Estimate Model Parameters

(Model outputs in $ per 1,000 vkm)

	Passenger traffic						Freight traffic			
	Motor-cycle	**Personal car**	**Pickup**	**Small bus**	**Medium Bus**	**Large Bus**	**Delivery Van & Small Truck**	**Medium Truck**	**Heavy Truck**	**Truck & Trailer**
Without-Project										
Quang Binh R1										
VOC										
$Base_{VOC}$	63.8	298.9	298.9	761.9	758.5	1436.4	469.3	455.0	761.9	458.5
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	3.4	27.4	27.4	32.1	32.1	769.1	99.3	96.6	32.1	96.6
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Quang Binh R2										
VOC										
$Base_{VOC}$	63.0	297.4	297.4	758.5	758.5	1429.8	455.0	455.0	704.9	1417.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	3.4	27.4	27.4	32.1	32.1	769.1	96.6	96.6	61.6	140.8
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Quang Binh R3										
VOC										
$Base_{VOC}$	86.7	386.3	386.3	875.5	758.5	1749.8	552.0	455.0	1240.3	2255.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	3.4	27.4	27.4	32.1	32.1	769.1	96.6	96.6	61.6	140.8
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nghe An										
VOC										
$Base_{VOC}$	86.7	386.3	386.3	875.5	472.2	1749.8	395.4	366.9	1240.3	2255.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	3.4	27.4	27.4	32.1	472.2	769.1	293.5	366.9	61.6	140.8
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Quang Tri										
VOC										
$Base_{VOC}$	54.5	360.9	360.9	472.2	472.2	932.5	366.9	366.9	1019.4	1828.4
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	0.0	0.0	0.0	334.9	472.2	733.9	464.3	366.9	105.5	95.0
E_{TTC}	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
With-Project										
Quang Binh R1										
VOC										
$Base_{VOC}$	37.9	217.9	217.9	288.6	288.6	527.0	319.5	319.5	485.0	540.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	4.5	19.6	19.6	49.8	49.8	197.2	0.0	0.0	0.0	0.0
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Quang Binh R2										
VOC										

	Passenger traffic						Freight traffic			
	Motor-cycle	**Personal car**	**Pickup**	**Small bus**	**Medium Bus**	**Large Bus**	**Delivery Van & Small Truck**	**Medium Truck**	**Heavy Truck**	**Truck & Trailer**
$Base_{VOC}$	37.9	217.9	217.9	288.6	288.6	527.0	319.5	319.5	485.0	540.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	4.5	19.6	19.6	49.8	49.8	197.2	0.0	0.0	0.0	0.0
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Quang Binh R3										
VOC	37.9	217.9	217.9	288.6	288.6	527.0	319.5	319.5	485.0	540.9
$Base_{VOC}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E_{VOC}										
TTC										
$Base_{TTC}$	4.5	19.6	19.6	49.8	49.8	197.2	0.0	0.0	0.0	0.0
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Nghe An										
VOC										
$Base_{VOC}$	37.9	217.9	217.9	288.6	288.6	527.0	319.5	319.5	485.0	540.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	4.5	19.6	19.6	49.8	49.8	197.2	0.0	0.0	0.0	0.0
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Quang Tri										
VOC										
$Base_{VOC}$	37.9	217.9	217.9	288.6	288.6	527.0	319.5	319.5	485.0	540.9
E_{VOC}	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TTC										
$Base_{TTC}$	4.5	19.6	19.6	49.8	49.8	197.2	0.0	0.0	0.0	0.0
E_{TTC}	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0

TTC = travel time cost, vkm = vehicle kilometer, VOC = vehicle operating cost.
Source: Quang Binh and Ngeh An: HDM-4 Reports. 2016. *MT RUC Components per 1000 vehicle-km* and *Pavement Condition Summary*: Kon Tum DT675A; Quang Tri: Note a and HDM-4 Reports. 2016. *MT RUC Components per 1000 vehicle-km* and *Pavement Condition Summary*: R6901 R13S-Paktaphan section. From 2021, Quang Tri road without improvement is expected to be at the maximum IRI and corresponding constant VOC and TTC.

29. The parameters in Table 15 were used alongside the forecasted IRIs following Equations (1) and (2) to compute the VOC and TTC for each vehicle type across the years, in the without- and with-project scenarios. The difference in VOC and TTC represent the cost savings or benefits to normal traffic per 1,000 vkm travelled. The final VOC and TTC savings estimate for each vehicle type is computed by multiplying the cost savings estimates (expressed in $/1,000 vkm) by the total distance travelled by normal traffic (expressed in vkm), which is the product of traffic forecast and subprojects' road length.[10]

30. Summing the VOC and TTC for all each vehicle type produces the overall road user costs in the without-project scenario. The overall road user costs in the with-project scenario is derived similarly. The total incremental VOC and TTC savings (associated with normal traffic) are derived by taking the difference in without-project and with-project VOCs and TTCs.

31. **Generated traffic benefit**. As mentioned, the benefits to generated traffic is assumed to be half (50%) of normal traffic's savings. For each vehicle type, the benefits accrued to generated traffic is computed by first multiplying normal traffic's VOC and TTC savings by 50% to compute

[10] For each vehicle type of normal traffic, the vkm travelled equal (i) average daily traffic (expressed in vehicle/day or equivalently trip/day in Table 6), multiplied by 365 days, multiplied by (iii) the road length (km/trip). The respective road lengths are 7.6 km, 8.0 km, and 23.3 km for the Quang Binh, Nghe An, and Quang Tri subprojects.

the benefits on a per-thousand-vkm basis. Secondly, the per-thousand-vkm benefit is multiplied with the total distance travelled by generated traffic by vehicle type to estimate the final road use benefit for generate traffic.[11]

32. **Diverted traffic cost savings**. For the diverted traffic, avoided VOC and TTC were computed by multiplying the per-vkm VOC and TTC (Table 15) with the total reduced travelled distance, which are expressed in vkm (Rows C_4 in Tables 9 and 10). Since diverted traffic is non-incremental, the entirety of the reduced VOC and TTC are counted as project benefits.

33. **Economic externalities** - **road accidents**. Road accidents frequency in Viet Nam is estimated to be 4.77 fatal injuries and 592.4 non-fatal injuries for every 1 million vkm. The incremental change in vkm is computed by subtracting the vkm travelled by generated traffic from the reduced vkm travelled by diverted traffic. If the difference is positive (reduced diverted traffic vkm greater than generated traffic vkm), then there is an decrease in distance travelled, thereby reducing road accidents. In this case, there is a positive externality or a project benefit due to reduced total vkm travelled. Conversely, if the difference is negative, the total vkm travelled increases, and there is a negative externality or project cost. The net changes in vkm travelled are presented in panel A in Table 16.

34. A 2005 World Bank project appraisal report estimated the cost of fatality and non-fatal injuries caused by road accidents.[12] After adjustment, the value of fatality and non-fatal injuries is $39,831 and $1,138 respectively per instance. Multiplying the net change in vkm travelled by the cost of fatal and non-fatal injuries yield the net change in road accident costs.

Table 16: Derivation of Road Accident Benefit and Costs due to Changes in vkm Travelled

	2020	2025	2030	2035	2040
Quang Binh					
A. Distance travelled (vkm)					
Generated traffic (A_1)	0	0	1,131,973	1,342,734	1,591,056
Diverted traffic (A_2)	0	1,079,661	1,079,661	1,079,661	1,079,661
Net change in distance travelled (A_3=A_1+A_2)	**0**	**1,079,661**	**-52,312**	**-263,073**	**-511,394**
B. Change in road accident instance (instance)					
Fatality (4.8 incidence/million vkm) (B1 = A3*4.8)	0.0	5.2	-0.3	-1.3	-2.5
Injury (592.4 incidence/million vkm) (B1 = A3*592.4)	0.0	639.6	-31.0	-155.8	-302.9
C. Change in road accident costs (US$)					
Fatality (39,831 $/incidence) (C1 = B1*39,831)	0	206,419	-10,001	-50,297	-97,773
Injury (1,138 $/incidence) (C2 = B2*1,138)	0	727,874	-35,267	-177,355	-344,766
Total (C_3=C_1+C_2)	0	934,293	-45,268	-227,652	-442,539
Nghe An					
A. Distance travelled (vkm)					
Generated traffic (A_1)	0	1,152,979	1,187,123	1,224,431	1,288,044
Diverted traffic (A_2)	568,800	881,600	1,272,000	1,504,800	1,676,000
Net change in distance travelled (A_3=A_1+A_2)	568,800	-271,379	84,877	280,369	387,956
B. Change in road accident instance (instance)					
Fatality (4.8 incidence/million vkm) (B1 = A3*4.8)	2.7	-1.3	0.4	1.3	1.9
Injury (592.4 incidence/million vkm) (B1 = A3*592.4)	337.0	-160.8	50.3	166.1	229.8
C. Change in road accident costs ($)					
Fatality (39,831 $/incidence) (C1 = B1*39,831)	121595	-58014	18145	59936	82935

[11] Similar to normal traffic, the vkm travelled equal (i) (i) average daily traffic (expressed in vehicle/day or equivalently trip/day in Table 6), multiplied by 365 days, multiplied by (iii) the road length (km/trip).

[12] World Bank. 2005. *Project No. 33327 Vietnam Road Safety Project*. Project Appraisal Document

	2020	2025	2030	2035	2040
Injury (1,138 $/incidence) (C2 = B2*1,138)	428767	-204568	63981	211345	292445
Total (C_3=C_1+C_2)	550363	-262582	82126	271281	375380
Quang Tri					
Generated traffic (A_1)	0	0	2,952,992	3,219,862	3,637,089
Diverted traffic (A_2)	0	2,739,968	3,079,871	3,509,990	4,164,361
Net change in distance travelled (A_3=A_1+A_2)	0	2,739,968	126,879	290,128	527,271
B. Change in road accident instance (instance)					
Fatality (4.8 incidence/million vkm) (B1 = A3*4.8)	0.0	13.1	0.6	1.4	2.5
Injury (592.4 incidence/million vkm) (B1 = A3*592.4)	0.0	1,623.2	75.2	171.9	312.4
C. Change in road accident costs (US$)					
Fatality (39,831 $/incidence) (C1 = B1*39,831)	0	582,075	27,123	62,022	112,717
Injury (1,138 $/incidence) (C2 = B2*1,138)	0	2,065,417	95,642	218,701	397,463
Total (C_3=C_1+C_2)	0	2,647,492	122,766	280,723	510,180

vkm = vehicle kilometer.
Source: PPTA consultant.

35. **Economic externalities** - **carbon emission.** The carbon emission externality is computed similarly as the road accident externality. However, here a slight complication is that carbon emission varies by vehicle types. Hence, in the analysis, the vkm travelled must be further decomposed by vehicle types. When reduced vkm travelled for diverted traffic is greater than the increase in vkm travelled for generated traffic, there is a positive externality or a project costs.

36. The Government of United Kingdoms' indicative carbon emission for different vehicles are as follows: 75 gram of carbon per vkm for motorcycles; 162 gram per vkm for personal cars; 77 gram per passenger km for buses; and 182 per ton-km for trucks.[13] Lastly, the social cost of carbon emission is valuated at $36.3 per ton at 2016 prices, increasing by 2% per annum. For each vehicle types, the economic externality is derived by multiplying the net change in vkm travelled by the carbon emission rate per vkm travelled, and finally by the unit social cost of carbon.

37. **Economic Analysis** - As a final step, the various costs and benefit streams are combined to compute the economic internal rate of return summary metric. Individually, the three subprojects yield an economic internal rate of return of 12.1%, 14.0%, and 15.1%, respectively. At the 9% economic discount rate, the economic net present values (ENPVs) are $2.1 million, $2.5 million, $5.2 million, respectively. The subprojects' economic resource flow statements are presented in Annex 1.

38. Table 18 presents the economic internal rate of returns and the sensitivity analysis of each road subproject. The results indicate that the economic viability is robust against downside risks.

[13] Sources: For car and motorcycle, UK Parliament publications, June 2007, the Government's Motorcycling Strategy: Government's Response to House of Commons Transport Committee; for bus, UK Government. website:http://directgov.transportdirect.info/Web2/JourneyPlanning/ Accessed 2/4/2010.

Table 18: Sensitivity Analysis for Road Subprojects

	EIRR (%)	ENPV (million $)	SI (%)	SV
Quang Binh Base Case	**12.1%**	**2.09**		
+10% investment cost	11.1%	1.46	-0.89	-1.12
+10% maintenance	12.0%	2.00	-0.10	-10.21
-10% traffic forecast	13.1%	2.87	0.76	1.31
-10% VOC and TTC savings	10.6%	0.98	-1.31	-0.76
Nghe An Base Case	**14.0%**	**2.50**		
+10% investment cost	12.8%	2.02	-0.893	-1.12
+10% maintenance	13.9%	2.44	-0.074	-13.6
-10% generated traffic	13.7%	2.28	-0.256	-3.9
-10% VOC and TTC savings	13.4%	2.15	-0.448	-2.2
Quang Tri Base Case	**15.1%**	**5.20**		
+10% investment cost	13.4%	4.07	-1.131	-0.88
+10% maintenance	15.0%	5.06	-0.092	-10.9
-10% traffic forecast	15.2%	5.39	0.081	12.3
-10% VOC and TTC savings	14.4%	4.50	-0.446	-2.2

EIRR = economic internal rate of return, ENPV = economic net present value, SI = sensitivity index, SV = switching value, TTC = travel time cost, VOC = vehicle operating cost.
Source: Asian Development Bank estimates.

Annex 1 – Subproject Economic Resource Flow Statement

Table A1 – Economic Resource Flow Statement for Quang Binh Subproject

BASIC INFRASTRUCTURE FOR INCLUSIVE GROWTH - ROAD SUBPROJECTS - (CENRAL PROVINCES)
ECONOMIC ANALYSIS - ALL SUBPROJECTS

	unit	constant	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040
Timeline																	
Project construction period	flag	2019	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Project operation period	flag	2040	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1
Major O&M period	flag		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROJECT STATEMENT - COMBINED																	
Project Benefits																	
VOC savings		NPV															
Normal and generated traffic	mil USD	5.83	0.00	0.00	0.00	0.00	0.47	0.53	0.58	0.62	0.66	0.67	0.68	0.68	0.69	0.69	1.56
Diverted traffic	mil USD	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Time cost savings																	
Normal and generated traffic	mil USD	0.88	0.00	0.00	0.00	0.00	0.07	0.07	0.08	0.08	0.08	0.09	0.10	0.10	0.10	0.11	0.27
Diverted traffic	mil USD	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Avoided accidents																	
Generated traffic	mil USD	-4.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.84	-0.87	-0.91	-0.94	-0.98	-1.37
Diverted traffic	mil USD	4.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Avoided CO2 emission																	
Generated traffic	mil USD	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
Diverted traffic	mil USD	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total Project Benefits	**mil USD**	**8.56**	**0.00**	**0.00**	**0.00**	**0.00**	**0.55**	**0.61**	**0.66**	**0.70**	**2.08**	**1.25**	**1.23**	**1.21**	**1.18**	**1.15**	**1.78**
Project Costs																	
Investment costs	mil USD	5.80	0.00	2.68	3.35	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual value	mil USD	-0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintaince																	
Recurrent maintenance	mil USD	0.21	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Periodic maintenance	mil USD	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Project Costs	**mil USD**	**6.47**	**0.00**	**2.68**	**3.35**	**0.67**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**
Net Project Benefit	**mil USD**	**2.09**	**0.00**	**-2.68**	**-3.35**	**-0.67**	**0.52**	**0.58**	**0.63**	**0.67**	**2.05**	**1.22**	**1.20**	**1.18**	**1.15**	**1.12**	**1.75**
ENPV	mil USD	**2.09**															
EIRR	%	**12.14%**															

Table A2 – Economic Resource Flow Statement for Nghe An Subproject

BASIC INFRASTRUCTURE FOR INCLUSIVE GROWTH - ROAD SUBPROJECTS - (CENRAL PROVINCES)
ECONOMIC ANALYSIS

	unit	constant	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040
Timeline																		
Project construction period	flag	2019	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Project operation period	flag	2040	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1
Major O&M period	flag		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PROJECT STATEMENT - NGHE AN

	unit	NPV	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040
Project Benefits																		
VOC savings																		
Normal and generated traffic	mil US	2.44	0.00	0.00	0.00	0.00	0.28	0.29	0.29	0.30	0.30	0.31	0.30	0.30	0.29	0.29	0.41	0.50
Diverted traffic	mil US	4.70	0.00	0.00	0.00	0.36	0.38	0.41	0.44	0.47	0.51	0.54	0.58	0.63	0.68	0.73	0.86	0.96
Time cost savings																		
Normal and generated traffic time	mil US	0.31	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.06	0.08
Diverted traffic time savings	mil US	0.00																
Avoided accidents																		
Generated traffic	mil US	0.00																
Diverted traffic	mil US	0.00																
Avoided CO2 emission																		
Generated traffic	mil US	0.00																
Diverted traffic	mil US	0.00																
Total Project Benefits	**mil US**	**7.45**	**0.00**	**0.00**	**0.00**	**0.36**	**0.69**	**0.73**	**0.77**	**0.80**	**0.84**	**0.89**	**0.92**	**0.97**	**1.01**	**1.06**	**1.34**	**1.54**
Project Costs																		
Investment costs	mil US	4.50	0.00	2.08	2.60	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual value	mil US	-0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintaince																		
Recurrent maintenance	mil US	0.10	0.00	0.00	0.00	0.00	0.013	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Periodic maintenance	mil US	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Project Costs	**mil US**	**4.95**	**0.00**	**2.08**	**2.60**	**0.52**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Net Project Benefit	**mil US**	**2.50**	**0.00**	**-2.08**	**-2.60**	**-0.16**	**0.68**	**0.72**	**0.75**	**0.79**	**0.83**	**0.87**	**0.91**	**0.95**	**1.00**	**1.04**	**1.32**	**1.53**
ENPV	mil US	**2.50**																
EIRR	%	**14.03%**																

Table A3 – Economic Resource Flow Statement for Quang Tri Subproject

BASIC INFRASTRUCTURE FOR INCLUSIVE GROWTH - ROAD SUBPROJECTS - (CENRAL PROVINCES) ECONOMIC ANALYSIS	unit	constant	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040
Timeline																		
Project construction period	flag	2019	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Project operation period	flag	2040	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1
Major O&M period	flag		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROJECT STATEMENT - QUNAG TRI																		
Project Benefits																		
VOC savings		NPV																
Normal and generated traffic	mil US	1.69	0.00	0.00	0.00	0.00	0.12	0.17	0.22	0.26	0.29	0.15	0.13	0.12	0.10	0.08	0.32	0.49
Diverted traffic	mil US	3.08	0	0	0	0	0.29	0.30	0.32	0.33	0.35	0.36	0.38	0.40	0.42	0.44	0.59	0.82
Time cost savings																		
Normal and generated traffic	mil US	2.85	0.00	0.00	0.00	0.00	0.27	0.28	0.29	0.30	0.31	0.36	0.37	0.38	0.40	0.41	0.53	0.70
Diverted traffic	mil US	0.88	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12	0.13	0.15	0.19
Avoided accidents																		
Generated traffic	mil US	-12.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.67	-2.71	-2.76	-2.80	-2.85	-3.11	-3.51
Diverted traffic	mil US	20.71	0.00	0.00	0.00	0.00	2.38	2.45	2.51	2.58	2.65	2.72	2.78	2.84	2.91	2.98	3.39	4.02
Avoided CO2 emission																		
Generated traffic	mil US	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Diverted traffic	mil US	0.07	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Total Project Benefits	**mil US**	**16.88**	**0.00**	**0.00**	**0.00**	**0.00**	**3.18**	**3.31**	**3.45**	**3.59**	**3.72**	**1.04**	**1.07**	**1.11**	**1.14**	**1.17**	**1.87**	**2.70**
Project Costs																		
Investment costs	mil US	10.53	0.00	4.87	6.09	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Residual value	mil US	-0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintaince																		
Recurrent maintenance	mil US	0.31	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Periodic maintenance	mil US	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Project Costs	**mil US**	**11.68**	**0.00**	**4.87**	**6.09**	**1.22**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**
Net Project Benefit	**mil US**	**5.20**	**0.00**	**-4.87**	**-6.09**	**-1.22**	**3.13**	**3.27**	**3.41**	**3.54**	**3.68**	**1.00**	**1.03**	**1.06**	**1.10**	**1.13**	**1.83**	**2.66**
ENPV	mil US	**5.20**																
EIRR	%	**15.10%**																