ECONOMIC AND FINANCIAL ANALYSIS

A. Introduction

1. **Economic rationale.** Karnataka has an area of about 192,000 square kilometers (km) and a population of about 64 million. The state's rail network consists of only 3,089 km of track, and consequently the road network is a critical element of the state's transport infrastructure, and is essential for economic development. The road network in Karnataka—which consists of national highways (2%), state highways (9%), major district roads (22%) and rural roads (67%)—totals 230,690 km in length, including a core network of 24,200 km. Most of the road network has either a single or intermediate lane configuration (96%), and is in fair to poor condition. The government has recognized the importance of road development to support economic growth and proposed to develop all state highways to a minimum two-lane standard,[1] with financing provided through a combination of the state budget, public–private partnerships, and multilateral development bank funding.

2. **Project details.** The proposed Karnataka State Highways Improvement III Project will contribute to improving road transport connectivity in Karnataka by upgrading about 418 km of state highways to two- and four-lane standards, and reconstructing, widening and strengthening culverts and bridges. Five road sections, all part of the core road network, were identified for upgrading. The project roads are primarily single-lane configuration, and are located in rural areas, with fertile agricultural land along the road corridor. The surface of the selected road sections is poor for the majority of their length, and require rehabilitation or reconstruction, as well as capacity expansion to cater to the anticipated increase in traffic demand.

3. An economic analysis of the five project roads was carried out using the Highway Development Model 4 (HDM-4), and in accordance with Asian Development Bank guidelines.[2] The model requires input data on traffic, road geometry, pavement structure and condition, maintenance and improvement costs, and vehicle operating costs (VOCs). Detailed project reports prepared for Karnataka Public Works, Ports, and Inland Water Transport Department (KPWD) provided the required input data, and the project roads have been evaluated on the basis of the current traffic and cost assessment. Costs to the road agency and road users in with- and without-project cases were used to estimate the net benefits and to assess the economic viability of the project roads.

4. **Alternative and least-cost analysis.** About 10% of project road sections will require upgrading to four lanes. A policy-driven proposal of upgrading all road sections to four lanes was considered but not pursued based on projected traffic volumes and preliminary economic analysis. Two-wheeled vehicles represent 54% of the traffic on the project roads and are involved in about 32% of fatal accidents in India,[3] and therefore the remaining project road sections are designed as two-lane sections with paved shoulders to improve road safety. A lifecycle cost analysis was conducted to assess flexible, semi-rigid, and rigid pavement options for the project roads, and indicated that flexible pavement has a marginally lower cost than rigid pavement. As initial capital costs of flexible pavements are 20%–30% lower than rigid pavement options, a flexible pavement design was recommended for all project roads.

[1] Karnataka Public Works Department. 2009. *Karnataka Road Sector Policy.* Bengaluru.
[2] Asian Development Bank. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.
[3] Government of India, Ministry of Road Transport and Highways. 2016. *Road Accidents in India 2015*. Delhi.

B. Demand Analysis

5. **Current Demand.** Traffic volumes were obtained from classified traffic counts carried out on project road sections (Table 1). Traffic composition at aggregate level for all project road sections consists of two-wheeled vehicles (54%), cars and taxis (20%), trucks (14%), buses (5%), rickshaws (4%), tractors (2%), and bicycles (1%). Passenger vehicles are predominant (85%), and non-motorized traffic is not significant (1%) on project roads.

Table 1: Base Year Motorized Traffic on Project Road Sections

Project Road	Length (km)	AADT (units)	Share (%)	
			Passenger Vehicles	Goods Vehicles
1 Kollegal–Hannur Road	23.7	6,624	88	12
2 Chintamani–AP Border Road	39.8	7,250	81	19
3 Bengaluru–Magadi–Kunigal Road	50.9	9,817	83	17
4 Magadi–Near Somwarpet Road	165.4	2,347	90	10
5 Gadag–Honnali Road	138.2	2,572	85	15

AADT = annual average daily traffic; km = kilometers; AP = Andhra Pradesh.
Source: Karnataka Public Works Department detailed project reports (2016).

6. **Traffic growth forecast.** Future traffic consists of (i) normal traffic, predicted to grow in line with population and economic development; (ii) traffic diverted from alternative routes (competing corridors between the same origins and destinations); and (iii) generated traffic, corresponding to the release of latent travel demand and an increase in traffic frequency due to roadway improvements. Normal traffic growth is considered in both the with- and without- project scenarios, while diverted and generated traffic corresponds to incremental traffic volumes and is considered only in the with-project scenario.

7. **Normal traffic**. Normal traffic growth is based on observed vehicle growth rates in relation to economic growth in the state, and on the economic growth outlook for future years. During 2001–2015, the population in Karnataka grew at an average annual rate of 1.5%, while the gross state domestic product (GSDP) grew by 7.3% per year and the GSDP per capita by 5.7% per year.[4] During 2001–2015 vehicle registration in the state grew by 10.0% for motorcycles, 12.7% for cars, 4.4% for rickshaws, 12.6% for buses, and 13.4% for goods vehicles (Table 2). The corresponding GSDP elasticities for registered vehicle growth are 1.7 for cars and 1.8 for trucks. Based on forecasts by the International Monetary Fund, the economic growth rate for India was assumed to be 7.7% per year over 2016–2020, with tapered assumptions over subsequent years.[5] The state economy was assumed to grow in line with the Indian economy, as was the case during 2001–2015 (footnote 4). The GSDP elasticities of car and truck growth rates were conservatively assumed to decrease to 1.1 and 0.9 by 2039. Economic assumptions, estimated traffic growth rates, and traffic volumes by vehicle class are in Table 3 and 4.

[4] State of Karnataka, Directorate of Economics and Statistics. 2016. *Economic Survey Report 2015–16*. Bengaluru.
[5] International Monetary Fund. World Economic Outlook Database. https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/index.aspx (accessed July 2017).

Table 2: Registered Vehicles in Karnataka, 2001–2015

Year	Two-Wheel Vehicle	Car	Auto Rickshaws	Bus	Truck	All Vehicles
2001	2,723,983	334,064	170,772	29,437	111,120	3,472,735
2008	5,273,962	798,447	249,520	70,840	256,938	6,916,912
2015	10,301,290	1,786,254	311,052	145,594	643,173	13,800,567
Growth per year (%)	10.0	12.7	4.4	12.1	13.4	10.4

Source: Government of Karnataka, Transport Department. *Annual Report.* 2001–2015. Bengaluru.

Table 3: Estimated Economic Growth Rates, Elasticity, and Traffic Growth Rates in Karnataka
(%)

Parameter	2001–2015	2016–2020	2021–2025	2026–2030	2031–2035	2035–2039
Socioeconomic Growth Rates						
GSDP	7.3	7.7	7.2	7.0	6.5	6.0
GSDP per capita	5.7	6.1	5.6	5.4	4.9	4.4
Population	1.5	1.5	1.5	1.5	1.5	1.5
Elasticity						
Car	1.7	1.3	1.3	1.3	1.2	1.1
Trucks	1.8	1.0	1.0	1.0	1.0	0.9
Traffic Growth Rates						
Two-wheeled vehicle	10.0	10.0	9.5	9.0	8.0	6.5
Car	12.7	9.5	9.0	8.5	7.0	6.0
Bus	12.4	6.0	5.5	5.2	4.8	4.7
Rickshaws	4.4	5.5	4.5	4.8	4.2	4.2
Trucks	13.4	7.7	7.2	7.0	6.5	5.5

GSDP = gross state domestic product.
Source: Asian Development Bank estimates.

Table 4: Estimated Annual Average Daily Traffic on Project Roads, 2020–2039

Project Road		2020	2025	2030	2035	2039
1	Kollegal–Hannur Road	8,738	11,462	15,985	21,345	26,366
2	Chintamani–AP Border Road	7,643	9,628	13,331	17,958	22,280
3	Bengaluru–Magadi–Kunigal Road	13,647	20,694	28,878	38,520	47,429
4	Magadi–Near Somwarpet Road	4,225	8,708	12,290	16,588	20,605
5	Gadag–Honnali Road	3,385	6,822	9,732	13,396	16,875

Source: Asian Development Bank estimates.

8. **Diverted and generated traffic.** Diverted traffic has been estimated for all project roads based on an analysis of existing travel demand on competing corridor sections, and was estimated at 340–3,060 vehicles per day, depending on the road section. The magnitude of generated traffic depends on the estimated level of benefits that accrue to the project influence area as a result of the improved road conditions. Assuming a price elasticity of traffic demand of –1.3 for passenger vehicles and –0.8 for commercial vehicles, generated traffic volumes of 5%–15% were assumed for the project roads based on the extent of time and VOC savings.

C. Economic Analysis

9. **Project costs.** Financial construction costs are based on bill of quantities and unit rates, and are in accordance with the detailed project reports prepared by KPWD for the project roads. Financial costs of civil works vary between ₹52 million and ₹115 million per km (Table 5), with an average of ₹61 million per km for all project roads, including labor cess, physical contingencies, utility shifting, environmental management costs, construction supervision costs, and road agency costs. Financial land acquisition and resettlement costs range from ₹9 million to ₹96 million per km, or about 17%–83% of capital costs.

10. The surface of the project road sections is currently in poor condition, with an average international roughness index of 5. The analysis assumes that periodic maintenance needs are met in both with- and without-project cases. In the with-project scenario, maintenance costs are estimated on the basis of maintaining road conditions to an average international roughness index of 2.6. The without-project scenario considers maintenance costs to prevent roads from deteriorating further than their existing condition. Maintenance costs include (i) annual routine maintenance, including patching, crack sealing, edge repair, and cleaning of the drainage systems and structures; and (ii) periodic maintenance, with resurfacing at 5-years intervals. Routine maintenance costs are estimated to be about 1% of civil works costs, and periodic maintenance to about 10% of civil works costs.

Table 5: Project Costs

Project Road		Length (km)	Civil Works		Social Mitigation[a]	
			Cost (₹ million)	Cost per km (₹ million)	Cost (₹ million)	Cost per km (₹ million)
1	Kollegal–Hannur Road	23.7	1,521	64.2	342	14.5
2	Chintamani–AP Border Road	39.8	2,063	51.8	493	12.4
3	Bengaluru–Magadi–Kunigal Road	50.9	5,854	115.0	4,864	95.5
4	Magadi–Near Somwarpet Road	165.4	8,743	52.8	5,000	30.2
5	Gadag–Honnali Road	138.2	7,131	51.6	1,227	8.9
	All roads total	418.0	25,314	60.6	11,925	28.5

km = kilometer.
[a] Land acquisition, relocation and resettlement financial costs
Source: Asian Development Bank estimates.

11. Potential congestion costs during construction are considered marginal because the project roads are predominantly in rural areas with low traffic volumes. Project roads are in fair to poor condition, and as the road construction progresses, the condition of road sections will increasingly improve and lead to VOC and time savings on improved sections. In the terminal year of the project, residual values of assets were assessed by using a straight-line depreciation method. With an economic life of 20 years for flexible pavement and an analysis period of 20 years of operation, the residual value of project roads is negligible and assumed to be zero.

12. **Project benefits.** Tangible benefits of upgrading the project roads include higher vehicle speeds and improved riding quality, resulting in travel time and VOC savings during the analysis period (Table 6). Without the project, speeds will be significantly reduced, as road capacities will be reached earlier than with the project, which would in turn contribute to a higher rate of road degradation. The benefits considered in the analysis include road agency savings (maintenance), VOC savings, and time savings. The benefits of generated demand were valued at half the level of the benefits of base demand.

Table 6: Carriageway Configuration, Roughness, Travel Speeds in First Year of Operation

	Project Road	Length (km)	Carriageway (m)		Roughness (IRI, m/km)		Travel Speeds (km/hr)	
			Without Project	With Project	Without Project	With Project	Without Project	With Project
1	Kollegal–Hannur	23.7	5.5	7.0	6.3	2.6	28	77
2	Chintamani–AP Border	39.8	5.5	7.0	5.9	2.6	37	79
3	Bengaluru–Magadi–Kunigal[a]	50.9	7.0	14.0	5.0	2.6	29	79
4	Magadi–Near Somwarpet	165.4	5.5	7.0	5.5	2.6	28	77
5	Gadag–Honnali	138.2	5.5	7.0	5.5	2.6	28	78

hr = hour, IRI = international roughness index, km = kilometer, m = meter.

[a] Four-lane is between Bengaluru to Magadi (14m) and Magadi to Kunigal is 2 lanes (7m).
Source: Asian Development Bank estimates.

13. **Carbon dioxide emissions.** The project will result in an increase in carbon dioxide (CO_2) emissions during construction and operation. While the project will reduce emissions for existing traffic through improvements in speed and riding quality, the increased traffic volumes will result in an overall increase in CO_2 emissions during operation. CO_2 emissions were estimated at 47,300 tons for the entire construction period and at 7,900 tons for the first year of operation, and were valued at $36.3 per ton in 2016 terms, increasing at 2% per year in real terms, in accordance with the revised Asian Development Bank guidelines (footnote 2).

14. **Other benefits.** In addition to quantified benefits, the project will accelerate the economic growth of rural areas of the state that otherwise suffer from poor connectivity. The population connected through the project roads will benefit from improved access to social, health, education, market, and employment facilities, and in turn contribute to reduced poverty in project areas. Other unquantified benefits include accident cost savings, because improvements in road geometry, road signs, and markings are likely to reduce accidents, especially for four-lane roads with carriageway separation.

15. **Value of time.** The work value of time was derived from the net domestic product per capita in Karnataka (footnote 4), household consumption expenditure, and labor workforce participation data, and was estimated at an average of ₹80.3 per hour.[6] The value of non-working time is taken as 30% of the value of work time (Table 7). The value of time for freight in transit has not been considered in the analysis.

Table 7: Values of Passenger Working and Non-Working Time in Karnataka
(₹ per hour)

	Bus	Car	Two- and three-wheeled vehicles
Working Time	40.2	160.6	80.3
Non-working Time	12.1	48.2	24.1

Source: Asian Development Bank estimates.

[6] Population, net state domestic product, and household consumption expenditure data were used to calculate the income per capita. The labor workforce participation rate was used to further calculate the total number of employed persons and the income of employed persons. Assuming 2,400 working hours per year and using the shadow wage rate factor of 0.82, the average value of work time was estimated at ₹80.3 per hour, which was assumed to be the value of time for two- and three-wheel vehicle passengers. Car passengers were assumed to have a 100% higher value of time, and bus passengers a 50% lower value of time than the average time value.

16. **Key economic assumptions.** The economic analysis has been carried out using the HDM-4 model for all project road sections, on the basis of a comparison of costs and benefits in with- and without-project scenarios. The HDM-4 model requires input data on traffic, road geometry, road condition, pavement structure, maintenance and improvement standards, and VOC parameters. The with-project scenario includes improvement options (capacity augmentation, and pavement rehabilitation and reconstruction) based on existing pavement condition and capacity analysis. The without-project scenario assumes that no improvement will be made to the road, and that normal routine and periodic maintenance will occur. Traffic, costs, and other input data were based on the detailed project reports prepared by KPWD for the project roads.[7]

17. The economic analysis uses the domestic price numeraire presented in national currency. An analysis period of 23 years was used, including 3 years of construction (2018–2020) and 20 years of operation (2021–2040) following completion of construction. All costs and benefits are valued in monetary terms as of 1 July 2017, expressed in economic prices, and converted using an exchange rate of $1 = ₹64.73. A discount rate of 9% was used for calculating the net present value (NPV). A shadow exchange rate factor of 1.041, calculated from India's international trade data, is applied to tradable goods to convert into domestic prices.[8] Physical contingencies are included in the economic project costs, but price contingencies and financing charges are excluded from the economic analysis.

18. A shadow wage rate of 0.82 is applied to unskilled labor cost, based on minimum wages and construction industry wages in Karnataka for unskilled laborers.[9] Vehicle operating costs are derived from surveyed market price of vehicles, tires, lubricants and fuel. The economic price of fuel is taken as ₹29.8 per liter for petrol and ₹29.2 per liter for diesel, which excludes fuel excise duties and VAT. The economic cost of land acquisition is based on its opportunity cost as the equivalent loss of agricultural output over a 40-year period.[10] The economic cost of resettlement is based on the replacement of private and community structures and on the economic value of relocation and resettlement allowances given to displaced families.

19. **Economic analysis.** The results of the economic analysis, in terms of the economic internal rate of return (EIRR) and NPV, indicate that the proposed project road improvements are all economically viable, with EIRRs above 9.0% (Table 8). The overall EIRR for the project is 21.4%. Cost and benefit streams for the overall project are presented in Table 9.

20. **Sensitivity analysis.** Sensitivity analysis was carried out to investigate the economic viability of the project under adverse conditions (changes in costs, benefits, and key economic evaluation parameters). The following scenarios were assessed: (i) construction cost increased by 20%; (ii) VOC and travel time savings reduced by 20%; (iii) construction cost increased by 20%, and VOC and travel time savings reduced by 20%; (iv) a 2-year delay in construction; (v) value of time decreased by 20%; and (vi) no CO_2 emissions. The EIRRs of the project roads remain above 9% in all cases, demonstrating the overall robustness of the project, even with adverse variations in costs and benefits.

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[7] KPWD, Karnataka State Highways Improvement Project. 2016. *Detailed Project Report.* Bengaluru.

[8] International Monetary Fund. International Finance Statistics and Global Financial Stability Report databases. http://www.imf.org/en/publications/gfsr/issues/2016/12/31/fostering-stability-in-a-low-growth-low-rate-era (accessed June 2016).

[9] State of Karnataka, Department of Labour. 2016. *Karnataka Labour Journal 2015-16*. Bengaluru.

[10] Calculated as the average revenue per hectare for the 10 largest crops by area in Karnataka, and assuming a 2% real growth per year over a 40-year period. Agricultural data obtained from: (i) State of Karnataka, Department of Agriculture. *State Agricultural Profile*. 2013. Bengaluru. (ii) State of Karnataka. Department of Agriculture. Market price database of agricultural crops. http://krishimaratavahini.kar.nic.in (accessed June 2016).

Table 8: Sensitivity Analysis Results

Project Road	Base case	Costs: +20%	Benefits: –20%	Costs: +20% Benefits : –20%	2-year delay	Value of time: –20%	CO_2 emissions excluded
Economic Internal Rate of Return (%)							
1 Kollegal–Hannur	21.7	18.5	18.0	15.2	19.2	19.0	22.2
2 Chintamani–AP Border	17.7	14.9	14.5	12.0	16.0	15.6	17.8
3 Bengaluru–Magadi–Kunigal	23.0	20.0	19.4	16.8	21.1	20.6	23.1
4 Magadi–Near Somwarpet	18.1	15.7	15.2	13.0	18.2	16.1	18.4
5 Gadag–Honnali	24.4	21.5	21.1	18.4	24.8	22.3	24.6
All roads total	21.4	18.6	18.1	15.6	20.8	19.2	21.6
Net Present Value (₹ million)							
1 Kollegal–Hannur	1,864	1,614	1,232	981	1,532	1,410	1,950
2 Chintamani–AP Border	1,706	1,332	1,016	641	1,374	1,251	1,719
3 Bengaluru–Magadi–Kunigal	9,323	8,340	6,475	5,492	8,123	7,367	9,376
4 Magadi–Near Somwarpet	8,830	7,330	5,528	4,028	8,383	6,516	9,196
5 Gadag–Honnali	14,940	13,666	10,720	9,445	14,328	12,252	15,001
All roads total	36,664	32,282	24,970	20,588	33,740	28,796	37,241
Switching Value (%)							
1 Kollegal–Hannur	-	149	(59)	42	-	(82)	n/a[a]
2 Chintamani–AP Border	-	91	(49)	32	-	(75)	n/a
3 Bengaluru–Magadi–Kunigal	-	190	(65)	49	-	(95)	n/a
4 Magadi–Near Somwarpet	-	118	(53)	37	-	(76)	n/a
5 Gadag–Honnali	-	234	(71)	54	-	n/a	n/a
All roads total	-	167	(63)	46	-	(93)	n/a

( ) = negative, CO_2 = carbon dioxide, n/a = not applicable

[a] The switching value cannot be calculated: the economic internal rate of return remains above 9% with a 100% decrease.

Source: Asian Development Bank estimates.

Table 9: Cash Flow Stream for the Proposed Roads in Karnataka
(₹ million)

Year	Road Agency Costs		Road User Benefits					
	Capital Costs	Main-tenance Costs	VOC		Travel Time		CO_2 Savings	Net Benefits
			Normal Traffic	Generated Traffic	Normal Traffic	Generated Traffic		
2018	(5,286)	1,469	-	-	-	-	(23)	(3,841)
2019	(10,572)	119	-	-	-	-	(47)	(10,499)
2020	(10,572)	119	-	-	-	-	(48)	(10,500)
2021	-	(85)	943	15	2,201	47	(20)	3,099
2022	-	(85)	1,035	33	2,347	96	(23)	3,403
2023	-	1,288	1,484	51	3,119	116	(34)	6,024
2024	-	(85)	1,861	62	4,231	137	(43)	6,161
2025	-	(2,372)	2,030	79	4,528	157	(48)	4,374
2026	-	(85)	2,295	100	4,854	177	(55)	7,286
2027	-	(85)	2,528	120	5,199	198	(62)	7,896
2028	-	1,306	2,772	141	5,526	218	(70)	9,892

2029	-	(85)	2,642	144	5,871	238	(67)	8,743
2030	-	(2,372)	2,885	163	6,246	259	(75)	7,107
2031	-	(85)	3,232	188	6,653	280	(85)	10,183
2032	-	(85)	3,555	210	7,084	302	(96)	10,970
2033	-	1,314	3,888	234	7,499	323	(107)	13,150
2034	-	(85)	3,727	231	7,937	344	(104)	12,050
2035	-	(2,372)	4,065	254	8,410	366	(116)	10,606
2036	-	(85)	4,522	282	8,920	388	(132)	13,894
2037	-	(85)	4,956	307	9,461	411	(148)	14,901
2038	-	1,318	5,403	334	9,987	433	(165)	17,311
2039	-	(85)	5,215	326	10,536	456	(161)	16,287
2040	-	1,232	5,656	351	11,125	479	(179)	18,665
							EIRR	**21.4%**
							NPV @ 9%	**36,664.0**

() = negative, CO_2 = carbon dioxide, EIRR = economic internal rate of return, NPV = net present value, VOC = vehicle operating cost.
Source: Asian Development Bank estimates.

D. Financial Sustainability

21. The project will not generate revenue. During FY2015 the government of Karnataka allocated ₹25.23 billion to KPWD for the maintenance of roads and bridges, of which ₹12.20 billion was allocated for the maintenance of state highways and major district roads, including about 35% for routine maintenance, 50% for periodic maintenance, and 15% for special maintenance.[11] The actual expenditure of KPWD was 1% higher than the budget at ₹25.59 billion. The current national maintenance norms require about ₹100,000 annually per lane kilometer for state highways and ₹60,000 per lane kilometer for major district roads.[12] The annual maintenance requirements for state highways and major district roads in Karnataka are therefore estimated to about ₹6.30 billion per year, in line with the actual expenditure of about ₹6.10 billion for routine and special maintenance. The annual average incremental recurrent costs associated with the project are otherwise estimated to be about 1.0% of the maintenance budget of KPWD in FY2016, and it is therefore reasonable to expect that the budget allocated will be sufficient to meet the maintenance costs.

22. The project contracts are on a hybrid annuity public–private partnership model, and the contracts include 7 years of post-construction operation and maintenance. Under hybrid-annuity contracts, 75% of the estimated project cost would be paid to the contractor on a milestone basis during construction. The balance of the project cost and the cost of maintenance would be paid in specified semi-annual payments over a period of 7 years following completion of construction. This approach shifts from traditional construction contracts to contracts focused on output delivery and sustainable asset maintenance. The hybrid annuity contracts therefore promote sustainable maintenance of the project roads by the private sector, under the supervision of KPWD.

[11] Government of Karnataka. KPWD. *Management Information System Annual Report 2014–15*. 2015. Bengaluru.
[12] Calculated based on bill of quantities, and 2016 unit rates, and on guidelines from the Indian Road Congress. *Design, Construction and Maintenance of Flexible pavements*. 2009. New Delhi.