ECONOMIC ANALYSIS

A. Project Rationale

1. Traffic congestion in Kathmandu valley has become serious as roads have become saturated. Projections indicate that the valley's population will double in 10 years to 4 million.[1] The number of vehicles grew from 50,000 in 1990 to around 462,000 in 2009. Significant costs in terms of lost time, wastage of fuel, and pollution directly affect management of urban transport in the valley. The project is expected to improve the urban transport system through rationalization of public transport, with investments in pilot routes, implementation of traffic management measures, pedestrianization of heritage routes within the city center, and air quality monitoring. The investment will result in traditional mobility benefits savings in travel time for users, lower vehicle operating costs (VOCs), and improvements in the safety and quality of public transport services. The rationale for government intervention is sound because (i) many of the urban transport services entailed are public goods; and (ii) improvements to the transport system will protect public welfare through a hygienic environment, and will prevent costs associated with negative externalities such as pollution and climate change. Through an improved urban transport infrastructure and institutional, management, and behavior changes, the government aims to address health, safety, and environmental issues, promoting a more sustainable and pro-poor approach to urban transport development to reduce undesirable social impacts.

B. Demand Analysis

2. Based on a 2009 traffic survey,[2] an estimated total of 462,000 vehicles were on the major roads leading into central Kathmandu. The traffic counts and survey results were normalized through the application of seasonal factors to obtain annual average daily traffic figures based on peak and off-peak traffic conditions. The traffic volume by type of vehicle during varying traffic conditions and passenger occupancy is shown in Table 1.

Table 1: Traffic Volume and Annual Average Daily Traffic in Survey Areas

Vehicle Type	Traffic Volume			Total	Passenger
	Peak	Off-Peak	AADT[a]	%	Occupancy
Motorcycle	50,954	178,648	297,747	64	1.3
Car	9,168	38,708	64,513	14	2.5
Taxi	3,745	15,810	26,351	6	1.4
Utility (big car with loading capacity)	4,046	17,783	29,638	6	
Big Bus	190	1,388	2,314	1	33.0
Minibus	1,371	6,443	10,738	2	26.4
Microbus	2,470	10,892	18,153	4	12.3
Safa Tempos (Electric three-wheelers)	1,818	5,828	9,714	2	7.6
Heavy Truck	50	829	1,382	0	
Light Truck	45	827	1,378	0	
Total	**73,855**	**271,328**	**461,927**	**100**	

[a] AADT = annual average daily traffic.

Source: Technical Assistance to Nepal for Preparing the Kathmandu Sustainable Transport Project under (TA7243-REG) Preparing the Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia estimates.

3. Considering past growth patterns of gross domestic product (GDP), population growth, real income per capita growth, and transport elasticity of demand for different vehicle categories, traffic volume has been projected to increase from 461,927 in 2009 to 674,782 by 2015, and 895,802 by 2021. Elasticity values employed in previous studies in Nepal over the last decade are as follows: (i) 0.80–1.75 for passenger transport; (ii) 1.25 for freight transport; and (iii) 2.00 for motorcycles. Based on the demand elasticity and GDP growth,[3] annual traffic growth rates are assumed to be 5% for trucks and 7% for other vehicle types. The projected vehicle traffic and passengers are shown in Table 2.

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[1] The 2001 Kathmandu valley population was about 1 million. The present population is closer to 2 million.

[2] ADB. 2009. *Preparing the Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia Project*. Manila. The TA surveyed 11 major routes.

[3] Instead of government projections of GDP annual growth of 6%, a more conservative growth rate of 3.5%–4% was assumed for the analysis.

Table 2: Projected Traffic Volume of Vehicles and Passengers, 2009–2034

Year	Truck	Light Truck	Bus	Mini Bus	Micro Bus	Car, Taxi	Utility	Safa Tempo	Motor Cycle	Total
A. Annual Vehicle Numbers										
2009	1,382	1,378	2,314	10,738	18,153	90,864	29,638	9,714	297,747	461,927
2015	1,853	1,847	3,473	16,114	27,242	136,362	41,568	14,578	446,838	689,875
2021	2,483	2,475	5,154	23,913	40,427	193,432	58,965	20,679	565,392	912,921
2025	3,018	3,009	6,705	31,112	52,596	244,203	74,442	26,107	661,429	1,102,622
2031	4,044	4,032	9,950	46,169	78,052	326,799	105,598	37,034	799,027	1,430,313
2034	4,681	4,668	12,121	56,243	95,082	412,577	125,769	44,108	878,214	1,633,462
B. Annual Passenger Numbers										
2009			76,364	264,148	223,277	198,084		70,912	387,071	1,219,856
2015			114,602	396,414	335,079	297,269		106,421	580,889	1,830,674
2021			170,067	588,270	497,250	421,682		150,960	735,010	2,563,239
2025			221,261	765,353	646,934	532,363		190,583	859,858	3,216,351
2031			328,347	1,135,767	960,036	712,422		270,346	1,038,735	4,445,652
2034			399,987	1,383,576	1,169,503	899,418		321,986	1,141,678	5,316,149

Source: Technical Assistance to Nepal for Preparing the Kathmandu Sustainable Transport Project under (TA7243-REG) Preparing the Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia estimates.

4. To determine the composition of the public transport fleet to be expected as a result of the project, the existing and expected fleet composition was analyzed (Table 3).

Table 3: Public Transport Fleet Composition – Without and With the Project

Vehicle Type	Fuel	Without Project (existing fleet)	With Project (proposed fleet)	Average passenger occupancy
Safa Tempo (3 wheel)	Electric (battery)	603	400	7.3
Small Electric Bus (4 wheel)	Electric (battery)	0	(pilot routes)154	11
Gas Tempo (3 wheel)	LPG	430	200	7.3
Microbus (6-14 seats)	Diesel	1,832	1,400	12.3
Minibus (15-25 seats)	Diesel	2,818	2,900	24.6
Full-sized bus	Diesel	14	50	33
Total		**5,697**	**5,104**	

Source: Technical Assistance to Nepal for Preparing the Kathmandu Sustainable Transport Project under (TA7243-REG) Preparing Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia estimates.

5. With the project, the number of vehicles decreases but the fleet capacity and number of people moved remain about the same. The new vehicles will be introduced over a 3-year implementation period from 2012 to 2014. In addition to improvements in public transport services, restrictions on private car usage in the city center (pedestrianization, parking limitation, etc.) will favor a gradual change from usage of private vehicles to public transport. A 10% modal shift is estimated to occur once the project has been implemented.

C. Least-Cost Analysis

6. Least-cost analysis attempts to identify the least-cost project option for supplying output (either goods or services) to meet forecast demand. Among the subprojects, the selection of the least-cost alternative ensures productive efficiency. The analysis does not provide any indication of economic feasibility of the project components, as a least-cost option may have costs that exceed its benefits.[4] In tandem, a benefit–cost analysis is undertaken by comparing the cost stream of the least-cost solution with the benefit stream to determine the net present value. Because of lack of sufficient data and feasible alternatives that provide comparable benefits, the analysis is limited to the two major outputs of the project: (i) improvements to Bishnumati Link Road (BLR) junctions, and (ii) public transport improvement (operation of electric buses on pilot routes in the city center). Alternative designs for the public transport option that seem to be reasonable to consider could include compressed natural gas minibuses or alternative fuel vehicles that do not require the infrastructure investment of trolleybuses (catenary system). These options will be assessed while preparing a feasibility study during initial project implementation.

[4] ADB. 2006. *Guidelines for the Economic Analysis of Projects*, Appendix 19. Manila.

1. Junction Improvements

7. Construction of a cable-stayed bridge in Dallu bridge junction (option 1) will reduce traffic congestion in the Bishnumati Link Road (BLR). The most technically feasible project alternative is the construction of a bridge south of the existing Dallu bridge and a bridge north of Teku (option 2). The benefits of reducing traffic congestion and air pollution (i.e., savings in VOCs caused by increased vehicle speed) are assumed to be same for both options. Construction of the two options is assumed to be undertaken from 2011 to 2013, with benefits accruing from 2014 onward. Based on the cost streams, option 2 is the least-cost option ($6.634 million) compared with option 1 ($8.855 million). Option 2 has been chosen (Table 4).

2. Public Transport Operation

8. The operation of 154 14-seat electric buses on two pilot routes (option 1) will help to reduce traffic congestion and air pollution in central Kathmandu. The most technically feasible project alternative is the operation of 17 trolleybuses under public–private partnership, with the government constructing electric overhead wires (option 2). The benefit from both options is assumed to reduce traffic congestion and air pollution to provide a better, faster public transport service to about 34,000 people daily. Costs are estimated for both options. The infrastructure will be built from 2011 to 2013, and operation of the buses will start from 2014 onward. Based on the cost streams, option 1 is the least-cost option ($5.03 million) compared with option 2 ($5.27 million). Option 1 has been chosen (Table 4).

Table 4: Least-Cost Analysis: Junction Improvement and Public Transport Operation

Economic costs	Junction Improvement		Public Transport Operation	
	Option 1: Construction of Cable-Stayed Bridge	Option 2: Construction of Two Bridges	Option 1: Operation of Electric Microbuses	Option 2: Operation of Trolleybus
Capital Cost	8.552	6.262	1.906	1.626
O&M[a] and Equipment Replacement	0.303	0.371	3.128	3.644
Total	**8.855**	**6.634**	**5.034**	**5.271**

[a] O&M = operation and maintenance.
Source: Technical Assistance to Nepal for Preparing the Kathmandu Sustainable Transport Project under (TA7243-REG) Preparing the Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia estimates.

D. Identification and Comparison of Project Costs and Benefits

9. The estimated economic benefits are based on a comparison of with- and without-project cases. Without the project, traffic becomes increasingly congested and average traffic speed remains low, resulting in high VOCs. With the project, average traffic speed increases thanks to the improvements under the project, thus reducing VOCs. The cost–benefit analysis covers a 20-year period and uses 2010 domestic prices.

10. **Economic costs** are mainly the project investment and operation and maintenance (O&M) costs. Given the complexity of estimating the country-specific economic opportunity cost of capital (EOCC), a discount rate of 12% in constant economic prices is generally used as a proxy for EOCC in the economic analysis of ADB-financed projects. Financial costs are converted to economic costs by the standard conversion factor of 0.9[5] and the shadow wage-rate factor, estimated at 0.7 based on the minimum wage. Taxes and duties are excluded. Maintenance costs have been assumed to be 4% of capital costs.

11. **Economic benefits.** The project integrates components that complement each other, and hence aims to deliver significant benefits to economic activity and quality of life in Kathmandu valley. Many of these benefits cannot be quantified, so they are not captured in the analysis. Nonetheless, the following externalities are expected from the project:

(i) With the expected modal shift, stricter vehicle emissions control, and the introduction of cleaner vehicles, greenhouse gas (GHG) emissions could decline by 10%–15% from 385,580 metric tons per year in 2009 (footnote 2).

[5] The standard conversion factor of 0.9 is consistent with other recent projects in Nepal.

(ii) Improvement of air quality and a decrease in the annual average level of total suspended particulates (TSP) and particulate matter (PM_{10}) of 200 milligrams per cubic meter (mg/m^3) could have an impact on public health as it has been estimated that a reduction to international standards (50 mg/m^3) would avoid 2,000 hospital admissions, about 135,000 cases of acute bronchitis in children, over 4,000 cases of chronic bronchitis, and half a million asthma attacks.[6]

(iii) Traffic accidents are expected to reduce substantially in the project areas where traffic management and walkability (general walking conditions) are to be improved. All these expected benefits will be quantified at the beginning of project implementation, by conducting a general baseline survey.

12. The economic benefits were quantified in terms of VOC savings due to an increase in the average operating speed (peak and off-peak hours). Data was collected from the Department of Roads for several vehicle types to calculate VOCs under stop-start conditions. The VOCs of each vehicle type based on varying speed conditions are in Table5. These VOCs are also dependent on the level of road surface roughness measured at the international roughness index (IRI) in meters per kilometer (m/km). On average, road roughness in urban Kathmandu is IRI 4.0 m/km–IRI 6.0 m/km. VOCs have been calculated using the Highway Design and Maintenance Standards Model (HDM-4) equations.[7]

Table 5: Urban Vehicle Operating Costs "Stop-Start" Conditions
(NRs per kilometer)

Speed (km/hr)	Vehicle Type									
	Motorcycle	**Car**	**Utility**	**Light Truck**	**Truck**	**Multi-axle Truck**	**Micro Bus**	**Mini Bus**	**Bus**	**Safa Tempo**
10	4.62	22.30	26.11	37.62	45.18	43.67	36.22	30.84	40.52	8.77
15	4.28	20.56	23.84	34.26	41.43	39.88	33.26	28.43	37.04	8.13
20	3.91	18.68	21.38	30.59	37.18	35.62	30.17	25.82	33.32	7.43
25	3.55	16.80	18.92	26.91	32.94	31.36	27.08	23.21	29.59	6.74
30	3.18	14.91	16.45	23.24	28.70	27.11	23.99	20.59	25.86	6.05
35	2.82	13.03	13.99	19.57	24.45	22.85	20.89	17.98	22.13	5.35
40	2.45	11.15	11.53	15.90	20.21	18.59	17.80	15.37	18.41	4.66
45	2.09	9.27	9.06	12.23	15.96	14.33	14.71	12.76	14.68	3.97
50	1.72	7.39	6.60	8.56	11.72	10.08	11.62	10.15	10.95	3.27

Source: Technical Assistance to Nepal for Preparing the Kathmandu Sustainable Transport Project under (TA7243-REG) Preparing the Implementation of Asian City Transport–Promoting Sustainable Urban Transport in Asia estimates.

13. It has been estimated that improvements in the provision of electric vehicles to replace existing electric three-wheelers (Safa Tempos) will effectively reduce the VOCs of the new vehicles by 15% over the existing Safa Tempo VOCs. Based on this average daily benefit, the total project benefits in terms of revenue to Kathmandu's urban economy were calculated. Because of lack of data, only VOC benefits have been quantified in the analysis. To address this, data will be obtained at project start-up through a baseline survey to quantify other real benefits of the project, such as time savings, accident reduction, carbon dioxide emissions reduction, air quality improvement, walkability improvement, noise reduction (with electric vehicles), improved travel reliability, etc.

14. **Economic internal rate of return.** To calculate the economic internal rate of return (EIRR), the following steps were undertaken: (i) surveys undertaken during the study (traffic surveys, public transport surveys, etc.) have given information on total traffic, its composition (i.e., percentage of buses, cars, etc.), and vehicle occupancy (Table 1); (ii) this will determine the VOCs in the existing situation, i.e., without the project at the prevailing average vehicle speed (Table 5); (iii) improvements in public transport and traffic management will change the modal split, as public transport is being encouraged, and will also improve the average vehicle speed; (iv) with the project, the resulting VOCs are calculated from the improved vehicle speed

[6] ADB. 2006. *Country Synthesis Report on Urban Air Quality Management – Nepal.*. Manila.

[7] Thawat Watanatada, Clell G. Harral, William D.O. Paterson, Ashok M. Dhareshwar, Anil Bhandari, and Koji Tsunokawa, World Bank, 1987. *The Highway Design and Maintenance Standards Model*.

in Table 5; (v) the difference between the VOCs for the with- and without-project cases represents the economic benefits of introducing the project improvements; and (vi) the VOC benefits and EIRR are calculated. In the absence of detailed traffic modeling, it is assumed that the improved road network performance will (i) increase the average travel speed during peak hours from the existing level of 15 km per hour (kph) to 18 kph, and (ii) increase the average travel speed during off-peak hours from 25 kph to 28 kph. VOCs were calculated assuming increased vehicle speed resulting from the rationalization of public transport and traffic management. The result of the cost–benefit analysis indicates that the EIRR is estimated at 20.6% (peak traffic), higher than the EOCC, indicating reasonable economic viability of the project (Table 6). As significant unquantifiable net benefits are believed to be likely, all EIRRs are likely to be substantially underestimated.

Table 6: Economic Internal Rate of Return ($ million)

Year	Capital Costs	Maintenance Costs	VOC Savings	Net Benefits
2011	4.61			(4.61)
2012	6.91			(6.91)
2013	6.91			(6.91)
2014	4.61			(4.61)
2015		1.15	7.07	5.92
2016		1.15	7.31	6.16
2017		1.15	7.56	6.40
2018		1.15	7.81	6.66
2019		4.61	8.07	3.46
2020		1.15	8.33	7.18
2021		1.15	8.60	7.45
2022		1.15	8.87	7.22
2023		1.15	9.15	8.00
2024		4.61	9.44	4.83
2025		1.15	9.72	8.57
2026		1.15	9.93	8.78
2027		1.15	10.14	8.99
2028		1.15	10.34	9.19
2029		4.61	10.54	5.93
2030		1.15	10.74	9.58
2031		1.15	10.93	9.77
2032		1.15	11.11	9.95
2033		1.15	11.28	10.12
2034		1.15	11.44	10.29
			EIRR	**20.6%**

( ) = negative number
EIRR = economic internal rate of return, VOC = vehicle operating cost.
Source: ADB estimates.

15. A sensitivity analysis, undertaken to test the economic viability of the subproject and the investment program, determined the consequences of changes in the following variables: (i) 20% increase in investment cost possibly arising from a delayed implementation schedule or higher than expected inflation; (ii) 20% decline in benefits; and (iii) traffic growth rates decrease by 20%. The worst case scenario is a combination of the three. The results show that the quantified economic benefits are robust to the various sensitivity tests and the project remains economically viable in all cases. The results of the sensitivity tests are shown for the peak in Table 8.

Table 8: Results of Sensitivity Analysis (Traffic Peak Hours)

	EIRR
Base case	20.6
Capital costs increased by 20%	17.2
Benefits reduced by 20%	16.4
Decrease in traffic growth by 20%	18.8
Capital costs +20% and benefits –20%	13.2

EIRR = economic internal rate of return.
Source: ADB estimates.