ECONOMIC ANALYSIS

A. Scope of Economic Analysis

1. The project and associated policy-based loan (PBL) (the overall project) aim to address the problem of rising emissions through (i) initiatives to strengthen the public road transport network and shift traffic away from private cars to electric buses and nonmotorized options, (ii) energy efficiency measures for industry and buildings, and (iii) support for climate-resilient development through a flood control component. Overall project demand is based on existing traffic flows, energy consumption, and flood damage in Xiangtan. The overall project aims to meet the low-carbon targets of the Xiangtan Low-Carbon Development Plan, 2018–2030 by meeting existing demand while altering behavioral patterns away from conventional carbon-intensive supply sources.[1] The economic internal rate of return (EIRR) and net present value (NPV) for the overall project were calculated based on the most directly quantifiable economic benefits. The EIRR and NPV were also calculated individually for four categories of economic benefits: (i) urban transport, (ii) flood prevention, (iii) energy savings, and (iv) the hospital.

2. The PBL is intended to have wide-ranging effects covering all outputs of the project loan. The aim is to embed the changes introduced by the project for the long term through changes in behavior that will be reinforced by changes in policy, and to spread the activities beyond the geographical areas covered by the project loan. The benefits of the PBL cannot be distinguished from those of the project loan, as the policy and project components are designed to be interdependent. Therefore, a separate economic evaluation has not been conducted for the PBL since its impact will be captured through the benefits associated with the project outputs. The value of the PBL is allocated to the four categories in proportion to the share of the components in project costs.

B. Methodology

3. The approach follows the Asian Development Bank's (ADB) Guidelines for the Economic Analysis of Projects using a domestic price numeraire at 2020 constant prices and a 9% discount rate.[2] Taxes and subsidies, price contingencies, and interest during construction have been removed from financial prices. All benefit and cost flows are disaggregated into the resource categories of traded and non-traded items and skilled and unskilled labor. The following conversion factors were applied: shadow exchange rate factors (SERFs) of 1.02 for traded items and 1.0 for non-traded items (net of taxes), and shadow wage rate factors (SWRFs) of 1.0 for skilled labor and 0.75 for unskilled labor.[3] Operation and maintenance costs are set at a proportion of capital costs, and major replacement expenditure is included in the costs at 8-year intervals.

C. Urban Transport

4. A detailed transport model for the center of Xiangtan was created for the economic analysis. The model was used to create transport projections for the without-project case, based on existing transport sources and recorded commuter preferences, and for the with-project case,

[1] Summary of the Xiangtan Low-Carbon Development Plan, 2018–2030 (accessible from Appendix 2 of the Report and Recommendation of the President).
[2] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.
[3] The Sichuan Ziyang Inclusive Green Development Project used an SERF of 1.08 and an SWRF of 0.67, the Hebei Energy Efficiency Improvement and Emission Reduction Project used a standard conversion factor of 0.987 (the equivalent of an SERF of 1.013), and the Shanxi Energy Efficiency and Environment Improvement Project used an SERF of 1.03 and an SWRF of 0.75.

in which both the project and policy components of the loan alter transport options and preferences. The same rate of population growth is applied in both cases.

5. The capital cost for urban transport includes 100 battery electric buses, which are replaced every 8 years. The measurable benefits include a decrease in vehicle emissions, savings in vehicle operating costs (VOCs), and a reduction in vehicle crashes. The reduction in vehicle emissions consist of reduced emissions of carbon dioxide (CO_2) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). CO_2 is valued at the standard ADB price, escalated by 2% per year, and $PM_{2.5}$ is valued at $124,000 per metric ton; these values were used in the Guizhou Gui'an New District New Urbanization Smart Transport System Development Project, which was approved in August 2019.[4] Savings in VOCs arise from less congestion and shorter travel times for the cars that continue to enter the city center in the with-project case. Cost data per vehicle-kilometer (km) for internal combustion engine vehicles are taken from the Guizhou Gui'an project at $0.228 per vehicle-km. A savings of 5% of VOCs per vehicle-km relative to the without-project case is assumed to cover both VOC and time savings.[5] It is assumed that car crashes and the associated fatalities and injuries will be reduced by 50% because of improved traffic management and policy actions related to electric motorcycles, which are responsible for most of the crashes. Crash data for Xiangtan were used, and fatalities were valued at $295,000, the price used in the Guizhou Gui'an project.[6]

6. The EIRR for the urban transport category is 11.8%, and the NPV (at a 9% discount rate) is $25.2 million (Table 1). Sensitivity analysis shows that the economic viability component is not strongly affected by increases in costs or decreases in benefits. The capital cost would have to increase by 31% for the project to become marginal, and the largest benefit, CO_2 emissions reduction, would have to decrease by 34%.

Table 1: Economic Evaluation—Urban Transport

Present values at 9%	**Amount**
Costs	
Capital ($ million)	80.3
O&M ($ million)	68.3
Benefits	
CO_2 emissions reduction ($ million)	74.0
$PM_{2.5}$ emissions reduction ($ million)	1.2
VOC savings ($ million)	65.0
Crash reduction ($ million)	33.6
EIRR (%)	11.8
NPV ($ million)	25.2

CO_2 = carbon dioxide, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance, $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter, VOC = vehicle operating cost.
Source: Asian Development Bank estimates.

[4] This is the highest of the prices indicated in J. Grütter and K. Kim. 2019. E-Mobility Options for ADB Member Countries. *ADB Sustainable Development Working Paper Series*. No. 60. Manila: ADB. It was subsequently used in ADB. 2019. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Guizhou Gui'an New District New Urbanization Smart Transport System Development Project*. Manila. The price appears broadly equivalent to values used by official entities. For example, the Government of the United Kingdom estimate is $137,000 in 2017 prices (sourced from Department for Environment, Food and Rural Affairs, United Kingdom. *Air quality appraisal: damage cost guidance.* [accessed 12 March 2020])

[5] This is a conservative assumption since an assumption of an 8% saving was used in the analysis of the Guizhou Gui'an project.

[6] To be conservative in the calculations, it was assumed all nonfatal injuries are nonserious and are valued at $10,000.

E. Flood Prevention

7. The project's investment in urban resilience and flood prevention will generate benefits from the reduction in flood damage. Benefits are estimated as the difference in the value of the damage in the without-project case and the damage in the with-project case, with probability weights assigned to both cases. In the with-project case, it is assumed that damage from floods of one-in-ten-year or less severity will be prevented. Estimates of the economic value of annual flood damage for 2011–2017 from the Xiangtan Water Conservation Bureau were converted to 2020 prices. Data on rainfall levels since the 1960s were used to estimate a probability–damage relationship by comparing the magnitude of floods during 2011–2017 with the corresponding rainfall levels in those years and the frequency with which those rainfall levels occurred. The years were grouped according to the probability of the rainfall level in that year occurring, and the average of the damage estimates for those years was used as the value of the damage associated with that rainfall level. The probability-damage relationship and damage estimates were used to calculate the benefit of the component, which equals the sum of expected damages of floods of one-in-ten-year or less severity, or $5.8 million per year.

8. The EIRR for the flood prevention category is 15.0%, and the NPV (at a 9% discount rate) is $8.09 million (Table 2). Sensitivity analysis shows that the economic viability of this category is not sensitive to increases in costs, as the capital cost would have to increase by 58% for the project to become marginal. The economic viability is more sensitive to changes in benefits, particularly the likelihood of avoiding future floods and the value of avoided damage. The value of avoided damage would have to decrease by 21% for the project to become marginal.

Table 2: Economic Evaluation—Flood Prevention

Present Values at 9%	Amount
Capital cost ($ million)	11.3
Operation and maintenance cost ($ million)	19.1
Benefit flood reduction ($ million)	38.5
Economic internal rate of return (%)	15.0
Net present value ($ million)	8.1

Source: Asian Development Bank estimates.

F. Energy Savings

9. The energy savings category focuses on improving buildings to Excellence in Design for Greater Efficiencies (EDGE) standards, introducing energy savings in selected communities, and introducing improvements to the information and communication technology-based energy management systems currently in use in the city. The cost of the program's output 2 (information and knowledge platforms for informed decision-making and behavioral changes enabled) was allocated to the energy savings category. The largest source of energy savings is from the development of a multi-energy and utility management system at Xiangtan Jiuhua Industrial Zone covering 670 enterprises. Based on industry experience with operation of such systems, it is assumed that the system will generate savings of 20% of the current level of consumption. For valuation of energy saving, the average energy retail tariff of $0.08 per kilowatt-hour is used as a proxy for the average long-run supply price. Reductions in CO_2 emissions associated with the energy savings are included as benefits. The base case EIRR is 19.3%, and the NPV is $129.8 million (Table 3). Sensitivity analysis shows that the economic viability component is not strongly affected by increases in costs or decreases in benefits. The capital cost would have to increase by 65% for the project to become marginal, and the largest benefits, energy savings and CO_2 emissions reduction because of the multi-energy and utility management system, would have to decrease by 42%.

Table 3: Economic Evaluation—Energy Savings

Present Values at 9%	Amount
Capital cost ($ million)	107.8
Operation and maintenance cost ($ million)	76.5
Benefits	
Energy savings ($ million)	234.2
Emissions reduction ($ million)	79.9
Economic internal rate of return (%)	19.3
Net present value ($ million)	129.8

Source: Asian Development Bank estimates.

G. Hospital

10. The project will finance the construction of a new hospital for traditional medicine. The hospital is included in the project because it will be designed to low-carbon EDGE standards. Given (i) the difficulties in valuing a standalone hospital using the disability-adjusted life years impact methodology, (ii) the wide variation in standard cost effectiveness indicators used in cost-effectiveness analysis, and (iii) that the Xiangtan Municipal Government has already approved construction of the hospital, it is assumed that the health benefits of the hospital are sufficient to justify its construction.[7] Therefore, an annual health benefit to patients of $11.1 million is included in project benefits to cover the capital costs of the hospital at a discount rate of 9%, resulting in the hospital having an EIRR of 9% and an NPV of zero.

H. Overall Project

11. The EIRR for the overall project is 14.6%, and the NPV is $163.1 million, demonstrating that the project is economically viable. The largest sources of economic benefits are energy savings and reduction in CO_2 emissions. Sensitivity analysis shows that the project remains economically viable under likely scenarios (Table 4). The capital cost would have to increase by 38% or total benefits would have to decrease by 32% for the EIRR to decrease to the threshold. The cost and benefit streams of the overall project are shown in Table 5.

Table 4: Sensitivity Analysis for Overall Project

	Urban Transport		Flood Prevention		Energy Savings		Overall Project		
Item	EIRR[a] (%)	NPV[a] ($ million)	EIRR[a] (%)	NPV[a] ($ million)	EIRR[a] (%)	NPV[a] ($ million)	EIRR[a] (%)	NPV[a] ($ million)	SV (%)
Base case[a]							14.6	163.1	
Increase in costs of category									
10%	14.2	152.3	14.5	161.7	13.9	144.5	12.9	120.3	
20%	13.7	139.9	14.4	158.6	13.2	92.0	11.4	110.4	38.0
Decrease in benefits of category									
10%	14.2	150.8	14.7	164.7	13.6	131.7	13.0	57.8	
20%	13.8	136.9	14.4	155.4	12.6	100.2	11.2	(8.2)	32.0
Delay in implementation (1 year)							13.0	127.6	

[a] Of overall project.
EIRR = economic internal rate of return, NPV = net present value, SV = switching value.
Source: Asian Development Bank estimates.

[7] ADB's Guidelines for the Economic Analysis of Projects acknowledges that calculation of EIRR and NPV of construction of a hospital is not always feasible, and ADB's Handbook for the Economic Analysis of Health Sector Projects recommends cost-effectiveness analysis. A stand-alone hospital is particularly difficult to value since the disability-adjusted life years impact will be impossible to predict in a meaningful way. Standard cost-effectiveness indicators, such as cost per patient or cost per disability-adjusted life year, will also vary widely with factors like hospital location, specialization, and scale of operations.

Table 5: Economic Evaluation
($ million)

Year	Capital Costs: Urban Transport	Capital Costs: Flood Prevention	Capital Costs: Energy Savings	Capital Costs: Hospital	O&M Costs (Total)	Total Costs	CO_2 Reduction	$PM_{2.5}$ Reduction	VOC Savings	Traffic Crash Reduction	Flood Damage Reduction	Energy Savings	Hospital Patients	Total Benefits	Net Benefits
2021	8.59	1.17	11.36	6.97	0.00	28.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(28.08)
2022	27.33	3.71	36.12	22.15	0.00	89.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(89.31)
2023	31.94	9.43	42.21	25.89	2.15	111.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(111.63)
2024	26.10	0.00	34.49	21.15	2.15	83.89	0.00	0.00	0.00	0.00	3.48	0.00	0.00	3.48	(80.41)
2025	11.55	0.00	15.26	9.36	2.15	38.32	0.00	0.00	0.00	0.00	4.06	0.00	0.00	4.06	(34.26)
2026	0.00	0.00	0.00	0.00	17.27	17.27	13.35	0.02	15.19	4.67	4.64	29.30	11.14	78.31	61.04
2027	0.00	0.00	0.00	0.00	17.03	17.03	15.25	0.05	15.90	5.26	5.22	33.49	11.14	86.30	69.26
2028	0.00	0.00	0.00	0.00	16.82	16.82	17.15	0.08	16.30	5.84	5.80	37.67	11.14	93.98	77.16
2029	0.00	0.00	0.00	0.00	32.63	32.63	19.05	0.11	14.92	5.84	5.80	41.86	11.14	98.72	66.09
2030	0.00	0.00	0.00	0.00	20.87	20.87	20.95	0.14	13.60	5.84	5.80	41.86	11.14	99.33	78.45
2031	0.00	0.00	0.00	0.00	20.23	20.23	22.83	0.17	12.31	5.84	5.80	41.86	11.14	99.95	79.72
2032	0.00	0.00	0.00	0.00	24.71	24.71	24.70	0.20	11.13	5.84	5.80	41.86	11.14	100.67	75.96
2033	0.00	0.00	0.00	0.00	19.18	19.18	26.55	0.22	10.06	5.84	5.80	41.86	11.14	101.47	82.29
2034	0.00	0.00	0.00	0.00	18.78	18.78	28.39	0.26	9.07	5.84	5.80	41.86	11.14	102.35	83.57
2035	0.00	0.00	0.00	0.00	18.48	18.48	30.21	0.28	8.20	5.84	5.80	41.86	11.14	103.32	84.84
2036	0.00	0.00	0.00	0.00	157.65	157.65	32.01	0.30	7.42	5.84	5.80	41.86	11.14	104.36	(53.28)
2037	0.00	0.00	0.00	0.00	22.92	22.92	33.81	0.31	6.72	5.84	5.80	41.86	11.14	105.47	82.54
2038	0.00	0.00	0.00	0.00	33.05	33.05	35.59	0.33	6.10	5.84	5.80	41.86	11.14	106.65	73.59
2039	0.00	0.00	0.00	0.00	21.38	21.38	37.35	0.34	5.56	5.84	5.80	41.86	11.14	107.89	86.50
2040	0.00	0.00	0.00	0.00	22.52	22.52	39.12	0.35	5.08	5.84	5.80	41.86	11.14	109.17	86.65
2041	0.00	0.00	0.00	0.00	20.38	20.38	40.87	0.36	4.64	5.84	5.80	41.86	11.14	110.50	90.12
2042	0.00	0.00	0.00	0.00	19.81	19.81	42.62	0.37	4.25	5.84	5.80	41.86	11.14	111.87	92.06
2043	0.00	0.00	0.00	0.00	19.46	19.46	44.37	0.38	3.90	5.84	5.80	41.86	11.14	113.27	93.81
2044	0.00	0.00	0.00	0.00	19.12	19.12	46.11	0.39	3.59	5.84	5.80	41.86	11.14	114.73	95.60
2045	(10.55)	(1.43)	0.00	0.00	18.77	6.79	47.86	0.40	3.31	5.84	5.80	41.86	11.14	116.20	109.41

( ) = negative, CO_2 = carbon dioxide, O&M = operation and maintenance, $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter, VOC = vehicle operating cost.
Note: The economic internal rate of return is 14.6% and the net present value (at a discount rate of 9%) is $163.1 million.
Source: Asian Development Bank estimates.