ECONOMIC ANALYSIS

A. Introduction

1. The economic analysis of the Gansu Baiyin Integrated Urban Development Project covers three subprojects: (i) road, water supply, and wastewater systems in the Liuchuan Industrial Park (LIP) infrastructure development; (ii) technical and vocational education and training (TVET) for skills development at secondary level and for adults; and (iii) development of an intelligent transport system (ITS) for traffic security and public transport improvement. The economic analysis was carried out to determine whether the benefits envisioned to be generated by the project are sufficient to cover the cost of investments in each subproject and the project as a whole, as basis for evaluating their economic viability. The economic viability was assessed through a least-cost analysis and a standard cost–benefit analysis. The least-cost analysis of alternative options ensured whether options identified and included under the proposed project would represent the least-cost means to meet the proposed project objectives and forecasted growth in demand. The economic analysis also evaluated the individual subprojects through the cost–benefit analysis by comparing with-project and without-project scenarios in accordance with the Asian Development Bank (ADB) Guidelines for the Economic Analysis of Projects[1] and Handbook for the Economic Analysis of Water Supply Projects.[2]

B. Project Alternatives and Least-Cost Analysis

2. The least-cost analysis was mainly conducted for the LIP infrastructure development subproject because the TVET and ITS subprojects only involve equipment purchase and their scopes are very specific and predetermined based on detailed needs assessments. The analysis used the lowest present value of economic costs. Investment and operation and maintenance (O&M) costs were converted into economic cost and compared among alternative options with a discounted rate of 12% per annum. The analysis ensured the subproject adopted cost-effective engineering design options for (i) water intake plant locations in the Yellow River, installation of pump systems, and distribution pipeline materials for the water supply component; (ii) treatment processes and sewage pipeline materials for the sanitation component; and (iii) pavement materials for the road component. The results indicated that a selection of biological aerated filter technologies will save CNY1.1 million in economic capital costs and CNY2.5 million in O&M costs compared to cyclic activated sludge and anaerobic-anoxic-oxic activated sludge technologies over 25 years. Also over 25 years, the use of ductile iron piping for the water distribution pipeline will save CNY3.5 million in capital and O&M costs. Asphalt pavement can also reduce the investment and O&M costs over 25 years by CNY1.2 million.

C. Cost–Benefit Analysis

1. Economic Costs

3. Economic costs included (i) capital cost, including land acquisition and resettlement, and environmental mitigation and monitoring; (ii) cost for consultants; (iii) physical contingencies; and (iv) O&M costs. Economic costs were valued in local currency using domestic prices and expressed in economic terms using domestic price numéraire at constant 2014 prices. Financial costs of traded goods were adjusted to their respective economic values using a shadow exchange rate factor of 1.01, and the shadow wage rate for skilled labor was estimated at 1.00

[1] ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila.
[2] ADB. 1999. *Handbook for the Economic Analysis of Water Supply Projects*. Manila.

and for unskilled labor at 0.67.[3] Unskilled labor comprises 30% of the labor cost. Transfer payments, including taxes, duties, and interests, were excluded from the economic costs.

4. **Liuchuan Industrial Park infrastructure development**. The subproject comprises road, sanitation, and water supply components. The economic capital costs were estimated at CNY283.4 million for the road component, CNY227.9 million for the wastewater component, and CNY437.9 million for the water supply component. The O&M costs for the water and sanitation components were estimated at CNY27.6 million based on actual costs of chemicals, electricity, fuel, small repairs, water, and workers' wages. The road component recurrent cost includes staff, electricity, repair, and maintenance costs in Gansu province. The routine O&M cost is estimated at CNY2.0 million for the first year of operation.[4] The opportunity costs of acquiring land under the water and sanitation component over 25 years were estimated to be CNY0.19 million and for the road component CNY0.21 million.[5]

5. **Technical and vocational education and training enhancement**. The TVET subproject will finance upgrading of training facilities, training and testing equipment, information and communication technology equipment and software, educational materials printing, and workshops. After all transfer costs were deducted, the economic project cost was estimated at CNY16.7 million. The O&M cost comprised program staff costs of 7% of the capital cost; direct operating costs including administrative, utilities, and maintenance costs of 8%; and miscellaneous expenditures including budget support for out-of-pocket expense allowance for on-grant students of 5%.[6] Annual O&M costs were estimated at CNY3.4 million in real prices.

6. **Intelligent transport systems installation**. The ITS subproject comprises two systems. The traffic police ITS will establish an operations center, signal controls, electronic police, video monitoring and violation recording, and traffic guidance. The public transport ITS includes on-board equipment, bus stop and depot equipment, an operations center, and software and system installation service. The uninflated financial cost is CNY40.3 million. O&M costs for two ITSs were estimated based on actual costs of (i) system operation power consumption, (ii) hardware and software system maintenance, and (iii) network rental and miscellaneous maintenance. The annual O&M cost was projected at CNY4.3 million in real prices.

2. Economic Benefits

7. **Liuchuan Industrial Park infrastructure development**. The subproject comprises three components. The analysis for water supply and wastewater treatment was combined as benefits are interrelated. Willingness to pay (WTP) was assumed for improved water and sanitation services, improved health, and user resource savings.[7] The WTP prices of CNY2.5

[3] Based on the annual official statistics issued by the Government of the People's Republic of China (PRC).

[4] Actual O&M cost for roads with the same class in Lanzhou, Gansu was used. The routine maintenance costs are CNY1.2 per square meter (m^2) of road per year (short term), CNY6.0 per m^2 of road per year (medium term), and CNY12.0 per m^2 of road per year (long term); wages are CNY18,000 per year for 90 maintenance workers; and electricity costs are CNY627,800 per year. The routine maintenance cost increases by 6% every year.

[5] The cost of acquiring 0.2 square kilometers (km^2) of agricultural irrigated land was multiplied by the annual average output value of CNY2.6 million per km^2 agreed between farmers and the local governments. The projection was estimated over 25 years. As the farmers generally overestimate the net annual average output values for compensation, the projection is considered as a conservative proxy of opportunity cost of the agricultural irrigated lands.

[6] The figures are based on enrollment fees per student of CNY2,080 for room, CNY400 for board, and CNY600 for books and materials.

[7] The approach was considered acceptable as water supply and sanitation costs are billed together. Survey results showed that respondents had difficulty differentiating the values of water supply and sanitation.

per cubic meter for domestic users and CNY4.1 per cubic meter for nondomestic users were derived from the social survey.[8] For the road component, the economic benefit was estimated by calculating work-related travel time saving and valuing it based on road users' average wages. When the project is completed, in addition to internal vehicular traffic, the LIP's roads will serve for external trip destinations in three cities: Baiyin (Lanzhou)–Jingyuan–Pingchuan. The traffic demand forecasts of the area were simulated by using origin–destination model projections against road networks for with-project and without-project scenarios. The number of road users was derived using actual and projected origin–destination data in each traffic zone in 2013. The traffic forecast between Baiyin city district, Jingyuan county center, and Pingchuan city district (as origins) and the LIP (as destination) are estimated to increase from 1,180 vehicles (Baiyin city district), 556 vehicles (Jingyuan county center), and 536 vehicles (Pingchuan city district) by 2.0% annually during 2015–2019, 10.0% annually during 2020–2034, and 2.0% annually from 2035 thereafter.[9] For a conservative estimate, travel time savings for those not travelling for work were not included.[10] Average income per capita in the LIP was estimated to be CNY45,062 based on 2012 average annual income for industries in Baiyin.[11]

8. **Technical and vocational education and training enhancement**. The TVET subproject will improve access of agricultural workers, unemployed laborers, and surplus laborers to new and enhanced skills to increase employment opportunities. For improved industrial productivity, the analysis used increased wages for graduates and trainees of TVET service providers in Baiyin as a proxy for the benefit. Annual enrollment of the project's secondary TVET school was estimated to grow gradually over 6 years to reach a maximum of 1,000 students. In each year, graduates would find jobs in the LIP, where enough employment opportunities will be offered. The LIP employment capacity will accept an estimated additional 2,000 trained agricultural farmers and unemployed laborers annually. Based on the statistics in Gansu, a graduation rate of 86% was used for secondary vocational students and adult skilled training courses. The current hiring rate in Gansu and Baiyin would be maintained at 95% with the enhanced labor market database and information system financed under the subproject. Actual wages of 19 different industries in Gansu in 2012 were used to estimate the average wage for industrial workers.[12] In 2013, the average income of graduates of standard skills training at vocational and technological schools was CNY2,000 per month in Gansu, slightly higher than the minimum wage of CNY1,964. Students and trainees who benefitted from the TVET subproject were assumed to work as full-time workers for at least 5 years.[13]

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[8] The questionnaire survey and face-to-face interview were carried out in the direct project benefit areas during December 2013–February 2014. The sample size of the questionnaire survey was 433 people (the response rate was 96.9%) and for the interview survey 30 focus group discussions covered 350 people. Average figures were used as users' WTP because the survey design could not support a comprehensive contingent variation method. The figures are considered conservative based on the WTP used by the contingent variation method in recent loan projects in the PRC: CNY3.5–CNY4.3 per cubic meter for domestic users in the Chongqing Urban–Rural Infrastructure Development Demonstration II project and the Guangdong Chaonan Water Resources Development and Protection Demonstration project.

[9] The assumption is based on general increase phases (2.0% per annum) during 2015–2019 and 2035 onwards and an active LIP development phase (10.0% per annum) during 2020–2034. A percentage of the general increasing phase was derived from the increasing vehicle registration rate in Baiyin.

[10] Other benefits, e.g., vehicle operation costs, road accidents, and impact on local economy, measured by additional gross domestic product (GDP) growth were also not quantified for a conservative estimate.

[11] Baiyin Municipal Government. 2012. *Baiyin Statistical Yearbook 2012*. Baiyin. The economic benefit of time saving is assumed to be associated with personal income in the project area for people using cars, transport vans and buses, and other light vehicles. The average number of passengers per car was assumed at three people, of which 30% are traveling during work hours.

[12] Gansu Provincial Government. 2012. *Gansu Development Yearbook 2012*. Lanzhou: China Statistic Press.

[13] The analysis did not quantify benefits of transforming agricultural workers to industrial workers as the current agricultural workers' income varies significantly.

9. **Intelligent transport systems installation**. The benefits of the ITS installations are (i) avoided accident and losses (e.g., fatality, permanent injury, and property damage) under the traffic police ITS; and (ii) savings on passenger waiting time at bus stations under the public transport ITS. For avoided accident and losses, benefits were valued based on the severity of the accidents and the damage to life and property. Actual 2010–2013 statistics from Baiyin district were used for the analysis. Annual averages of injuries were 10 fatal injuries, 28 permanent injuries, 154 nonpermanent injuries, and 984 cases of property damage only. The project estimate to reduce the number of incidents by 10% is conservative.[14] For fatal accidents, benefit was estimated from labor output loss. Loss of potentially productive years due to a fatal accident was estimated at 20 years after considering average retirement age in the People's Republic of China and average age in fatal incidents in Baiyin. The portion of wage earners among total traffic casualties was assumed at 30%. Labor output loss was calculated by multiplying the loss of potentially productive years by the average annual income based on the figures in Baiyin at CNY45,062 in 2012. This was adjusted to the current using the gross domestic product growth rate of 7.5% per annum until 2020, 5.0% per annum during 2021–2025, and 3.0% per annum thereafter.[15] For nonfatal traffic injuries, benefits from the subproject were measured from avoided medical costs including hospitalization and labor output loss due to temporary disability during the recuperation period. Based on Baiyin's current statistics, temporarily disabled casualties spend an average of CNY183 per day for 7 days for medical costs. The estimation for casualties who become permanently disabled was the same as for fatal accident. From the statistics, the average loss in property damage (e.g., garages, roads, and vehicles) was estimated at CNY380 per incident.

10. The major benefit of the public transport ITS is savings on passenger waiting time at bus stops. In 2012, bus ridership in Baiyin district reached 130,000 per day, but the punctuality rate was 60%. The average waiting time at bus stops was 12 minutes. The installation of the ITS will improve the punctuality rate gradually to 80% in 2020 and 90% in 2030. This will shorten waiting times by 25% by receiving real-time traffic information from bus control terminals and bus drivers. The value of leisure time saving was estimated as 10% of average wages. Information boards will be installed at bus stops, assisting passengers to plan and adjust their trips. Other benefits not quantified are (i) improved traffic flow at congested intersections; and (ii) higher modal share of public bus with associated travel time and vehicle operating cost savings, and lower greenhouse gas emissions.

3. Economic Internal Rate of Return

11. The base-case economic internal rate of return (EIRR) calculation for the entire project is given in Tables 1 and 2. At a 12.0% discount rate, the project is economically viable. The EIRRs were computed at 14.9% for the overall project, 14.2% for the LIP infrastructure development subproject, 20.0% for the TVET enhancement subproject, and 19.9% for the ITS installation subproject. The estimated benefits of the project were considered conservative because many qualitative benefits were identified but not included in the analysis. The sensitivity analysis tested the effects of negative changes in key parameters. The sensitivity analysis found that the project remains economically viable in the face of a 10.0% decrease in benefits (13.3%), a 10.0% increase in capital cost (13.7%), and a 1-year implementation delay (12.9%). The

[14] The figure was assumed from the following reference: S. Ezell. 2010. *Intelligent Transportation Systems*. The Information Technology and Innovation Foundation. Washington D.C.

[15] In real terms, the GDP growth target under the PRC Twelfth Five-Year Plan, 2011–2015 is 7.5%. In the analysis, the national average was used and reduced gradually to give a conservative estimate of future growth of GDP.

switching value analysis indicated that the project is economically viable until the benefit decreases by 18.7% or the capital cost increases by 24.9%.

Table 1: Summary of Economic Internal Rate of Return and Sensitivity Analysis

Item	EIRR (%)	NPV (CNY million)	Sensitivity Indicator	Switching Value (%)
Subprojects				
LIP infrastructure development	14.2	144.1		
(i) Water and wastewater	14.8	116.5		
(ii) Road	13.2	27.6		
TVET enhancement	20.0	28.3		
ITS installation	19.9	36.3		
Whole Project				
(i) Base case	14.9	208.7		
(ii) Benefits decreased by 10%	13.3	93.2	5.4	18.7
(iii) Capital cost increased by 10%	13.7	133.1	4.0	24.9
(iv) Construction delay of 1 year	12.9	67.6	3.8	
(v) Combination of (ii), (iii), (iv)	10.6	(109.4)	3.8	

( ) = negative value, EIRR = economic internal rate of return, ITS = intelligent transport system, LIP = Liuchuan Industrial Park, NPV = net present value, TVET = technical and vocational education and training.
Source: Asian Development Bank estimates.

Table 2: Economic Internal Rate of Return for the Project, 2015–2040
(CNY million)

	Benefits				Costs							
Year	LIP Infra. Dev.	TVET	ITS	Total	Capital Costs	O&M Opp	Total	Net Benefits	Benefit decline 10%	Capital cost overrun 10%	1-year delay	Combined
2015	0.0	0.0	0.0	0.0	85.4	0.0	85.4	(85.4)	(85.4)	(94.0)	(85.4)	(94.0)
2016	0.0	0.0	0.0	0.0	303.3	0.5	303.8	(303.8)	(303.8)	(334.1)	(303.8)	(334.1)
2017	15.5	0.0	1.3	16.8	392.0	7.4	399.4	(382.6)	(384.3)	(421.8)	(399.4)	(438.6)
2018	17.0	0.0	4.7	21.7	143.6	8.2	151.8	(130.1)	(132.3)	(144.5)	(135.0)	(151.0)
2019	18.6	0.0	7.2	25.8	81.7	10.2	91.9	(66.1)	(68.7)	(74.3)	(70.2)	(80.6)
2020	193.7	0.0	10.5	204.1	0.0	38.0	38.0	166.2	145.8	166.2	(12.1)	(14.7)
2021	197.4	0.4	11.8	209.6	0.0	38.1	38.1	171.5	150.5	171.5	166.0	145.6
2022	201.4	1.3	13.2	215.8	0.0	38.3	38.3	177.5	155.9	177.5	171.3	150.4
2023	206.0	3.1	14.6	223.7	0.0	40.8	40.8	182.9	160.5	182.9	175.0	153.4
2024	211.3	5.4	16.3	233.0	0.0	38.7	38.7	194.3	171.0	194.3	185.0	162.6
2025	217.5	9.1	18.0	244.7	0.0	39.0	39.0	205.7	181.3	205.7	194.1	170.8
2026	224.1	14.3	19.8	258.2	0.0	39.2	39.2	219.0	193.2	219.0	205.5	181.0
2027	231.1	19.2	21.6	271.9	0.0	39.5	39.5	232.4	205.2	232.4	218.7	192.9
2028	239.0	23.8	23.5	286.3	0.0	45.9	45.9	240.4	211.8	240.4	225.9	198.8
2029	247.9	27.7	25.6	301.2	0.0	40.2	40.2	261.0	230.9	261.0	246.2	217.5
2030	251.8	31.1	27.9	310.8	129.4	40.5	169.9	140.8	109.8	127.9	131.2	88.2
2031	255.9	31.1	28.7	315.7	0.0	40.9	40.9	274.8	243.2	274.8	269.9	238.8
2032	260.1	31.1	29.6	320.8	0.0	41.4	41.4	279.4	247.3	279.4	274.3	242.7
2033	264.6	31.1	30.5	326.2	0.0	46.0	46.0	280.2	247.6	280.2	274.8	242.8
2034	269.3	31.1	31.4	331.8	0.0	42.4	42.4	289.4	256.2	289.4	283.8	251.1
2035	274.2	31.1	32.3	337.7	0.0	43.0	43.0	294.7	260.9	294.7	288.8	255.6
2036	279.4	31.1	33.3	343.8	0.0	43.7	43.7	300.2	265.8	300.2	294.0	260.2
2037	284.9	31.1	34.3	350.3	0.0	44.4	44.4	305.9	270.9	305.9	299.5	265.1
2038	290.6	31.1	35.3	357.0	0.0	56.1	56.1	301.0	265.3	301.0	294.2	259.2
2039	296.6	31.1	36.4	364.1	0.0	45.0	45.0	319.2	282.7	319.2	312.1	276.4
2040	303.0	31.1	37.5	371.5	0.0	45.8	45.8	325.7	288.5	325.7	318.3	281.9
NPV		**at 12%**						**208.7**	**93.2**	**133.1**	**67.6**	**(109.4)**
EIRR								**14.9%**	**13.3%**	**13.7%**	**12.9%**	**10.6%**

( ) = negative value, EIRR = economic internal rate of return, ITS = intelligent transport system, LIP = Liuchuan Industrial Park, NPV = net present value, O&M = operation and maintenance, Opp = opportunity cost, TVET = technical and vocational education and training.
Source: Asian Development Bank estimates.