ECONOMIC ANALYSIS

A. Introduction

1. The economic analysis was conducted to assess the economic viability of the project in accordance with the Guidelines for the Economic Analysis of Projects of the Asian Development Bank (ADB).[1]

B. Sector Contexts

2. Yangtze River Economic Belt (YREB) contributes about 45% of the economic output of the People's Republic of China (PRC) and accounts for over 40% of the PRC population. Based on its demographic and geographic assets, YREB has been earmarked as one of three key growth engines to ensure the PRC's future economic development. The average gross domestic product per capita was about $8,270 in Chongqing Municipality, which was about the same as the national average in 2015. Chongqing has a population of 33.7 million, of which more than 39% is rural. Despite its strategic importance and annual growth of over 10%, the challenges of urban–rural income disparities are still high in Chongqing and the progress is slow. In 2016, the ratio of the urban–rural average income was 3:1.

3. YREB has 40% of the PRC's freshwater resources; serves as the drinking water resource for 400 million people; provides 60% of total fisheries production; and has 20% of the total wetland area. Chongqing is a core part of the ecological conservation zone of the Three Gorges Reservoir, which plays a role in mitigating floods in the middle and lower Yangtze River reaches. Longxi River is located in major urban areas of Chongqing and is the primary tributary of Yangtze River. The middle and upper reaches of YREB face severe development challenges from flooding, increasing pollution, and pressure on natural resources management. Many areas suffer high economic damage and loss of life during floods, as well as chronic water pollution. Fast-paced industrialization and urbanization along the Longxi River corridor, without integrated river basin planning, has put pressure on water resources. The water quality in the rivers and lakes in the municipality already exceeds the national standard (class III) at various locations.[2]

C. Economic Rationale

4. Chongqing is facing more frequent and damaging floods together with serious environmental consequences as a result of rapid urbanization. Climate variability is likely to increase the frequency and severity of flooding. The government requested ADB to provide lending support to address key flood risk and water resources management issues in Changshou District, Dianjiang County, and Liangping District of Chongqing Municipality in an integrated manner, including water quality management, flood mitigation, nonpoint source pollution prevention, and related capacity-building activities.

5. **ADB's value addition.** The project will promote an integrated flood and environment risk management (FERM) approach. This will include formulating a pilot comprehensive FERM plan for the watershed as a prerequisite for other development plans to ensure priority for environment conservation. A nexus approach will be demonstrated for the inextricably intertwined flood (water)-waste (environment)-ecosystem under FERM through the integration of structural and

[1] ADB. 2007. *Guidelines for the Economic Analysis of Projects.* Manila.
[2] Following the PRC's Environmental Water Quality Standard (GB 3838-2002), up to class III water is suitable for drinking.

nonstructural measures. This approach will have a good demonstration effect for other regions, as the PRC needs to improve the management of its many small river basins facing issues similar to those of Chongqing.

D. Least Cost Analysis

6. Least cost analysis was completed for alternative engineering options of sewage pipe material. The net present value (NPV) of (i) reinforced concrete option was CNY553 per meter; (ii) double wall corrugated pipe high density polyethylene option was CNY549 million per meter; and (iii) the ductile iron option was CNY745 per meter. Option (ii) was the least cost option chosen for the project but was rejected because of poor performance in previous installments. Option (i) has been chosen for greater strength and lower costs than option (ii).

7. The major assumptions used for the least cost analysis are (i) the lifetime of the subprojects is 20 years, including a construction period of 5 years; (ii) all prices and costs are expressed in fourth quarter 2017 prices; (iii) economic benefits and costs are valued in the domestic price numeraire and expressed in yuan; (iv) physical contingencies of 5% are included in the investment cost; (v) taxes, duties, and price contingencies are excluded from the economic cost; (vi) the economic opportunity cost of capital is assumed at 9% per year; and (vii) a shadow exchange rate factor of 1.016 is used to convert the financial prices of traded goods to economic prices, non-traded outputs are valued at domestic market prices, and a shadow wage rate factor of 0.9 is used to convert the financial wage rate to an economic opportunity cost of labor.

E. Cost–Benefit Analysis

8. Cost–benefit analysis was conducted for the project based on the assumptions used for the least cost analysis. The projected economic benefit and cost flows were estimated for with- and without-project situations and projected over 20 years. The incremental economic benefit and cost flows provided the basis for calculating the economic net present value (ENPV) and economic internal rate of return (EIRR).

9. **Economic benefits**. The estimated economic benefits comprise three types of quantifiable benefits: (i) improved flood management, (ii) improved wastewater management and pollution control, and (iii) improved ecological conservation. The present value of the total project economic benefits is CNY4,855 million, broken down by the present value of improved flood management (CNY4,353 million); the present value of improved wastewater management and pollution control (CNY249 million); and the present value of improved ecological conservation (CNY253 million).

10. **Economic benefit of improved flood management.** The present value of improved flood management was derived from the present value of avoided flood losses attributable to improved flood protection. Project interventions for flood management include the construction of embankments in Changshou District, Dianjiang County, and Liangping District; dredging of silted sections of Liping River and its tributaries; and ecological measures as part of the embankment works to improve the riparian wetland habitat. This will provide protection against floods with a 20-year return frequency in urban areas and a 10-year return period in rural areas.

11. The financial value of avoided flood damage was derived using estimates of flood return periods and damage data from historical floods. Data on damage were updated to account for inflation and the growth of vulnerable assets resulting from development. The value of vulnerable assets was conservatively assumed not to increase in real terms over the forecast period.

Historical flood damage data were only available for Dianjiang County, one of the three jurisdictions benefiting from the flood protection measures. A hydrologic modeling approach was used to determine the area flooded for different return frequencies. Flood damages for these return frequencies were estimated as the flood area multiplied by the average unit area flood damage estimated using the historical data. The annualized financial values of flood damages were multiplied by corresponding flood occurrence probabilities and aggregated as the total annualized financial values of flood damages, which were subsequently converted to economic values using the standard conversion factor. The average annual values of flood damage without the project were estimated at CNY1.71 billion. The project will reduce average expected annual flood damage by CNY0.89 billion or 48%. The average annual value of avoided flood losses attributable to the project's improved flood protection is CNY0.82 billion. The ENPV of improved flood management was derived from the flow of the annualized economic values of flood damages using a 9% discount rate.

12. **Economic benefit of improved wastewater management and pollution control.** The present value of improved wastewater management from increased wastewater treatment was derived from willingness-to-pay (WTP) data for domestic wastewater service generated in a household survey. Project interventions for wastewater management include the construction of 28.5 kilometers of sanitary sewers in Changshou District, where an estimated 38,800 households will be connected to existing wastewater treatment plants. Project investments for wastewater treatment improvement comprise the construction of a wastewater collection network and capacity expansion of two wastewater treatment plants. The estimated mean WTP for wastewater management improvements is CNY0.81 per ton charged against the metered water use of customers receiving wastewater treatment services. Economic benefits were estimated by multiplying the mean WTP by the average annual water use of beneficiary households that will be connected to the wastewater collection network.

13. Project interventions for pollution control include the construction of bioretention filters on the embankments and related landscaping. The economic benefits for water pollution control have not been quantified because of lack of an applicable valuation method. However, these interventions also contribute to flood control by slowing and retaining flood flows and by impeding future encroachment onto the floodplain. For this reason, 5% of flood control benefits are allocated to account for the flood control contribution of this project intervention.

14. **Economic benefit of improved ecological conservation.** The present value of improved ecological conservation through green buffer zones and wetlands along riverbanks was derived from the benefits transfer approach. Ecological conservation facilities cover an area of 126.4 hectares. These facilities provide bank protection and erosion control, flood water retention, and aesthetic and ecological benefits. Literature values related to wetland amenity values in the PRC were applied to green buffer zones and wetland areas to be developed by the project. The selected value at 2017 prices is CNY74,400 per hectare.[3] The green buffer zones and wetlands along riverbanks also contribute to flood control by slowing and retaining flood flows and by impeding future encroachment onto the floodplain. For this reason, 5% of flood control benefits are allocated to account for the flood control contribution of this project intervention.

15. **Economic costs and benefits**. The economic costs include (i) investment costs (e.g., civil works, equipment, materials, land acquisition and resettlement, capacity development and project implementation support; and social and environment monitoring costs); and (ii) the cost of

[3] C. Tong et al. 2007. Ecosystem service values and restoration in the urban Sanyang wetland of Wenzhou, China. *Ecological Engineering*. 29. pp. 249–258. Total estimated benefits are CNY36,783 per hectare.

operation and maintenance. As shown in Table 2, the ENPV is CNY3,209 million and the EIRR is 23.2%. The EIRR exceeds the economic opportunity cost of capital, confirming the project's economic viability.

Table 1: Economic Internal Rate of Return for the Project
(CNY '000)

Year	Capital Investment	Incremental Sales Revenues	Recurrent Costs	Benefits			Net Annual Value
				Flood	Wastewater	Ecological	
2019	(566,053)	0	0	0	0	0	(566,053)
2020	(522,696)	0	0	0	0	0	(522,696)
2021	(320,784)	0	0	0	0	0	(320,784)
2022	(315,112)	0	0	0	0	0	(315,112)
2023	(212,634)	0	0	0	0	0	(212,634)
2024	0	0	(26,428)	733,750	41,627	42,660	791,609
2025	0	0	(29,084)	733,750	41,812	42,660	789,138
2026	0	0	(29,084)	733,750	41,838	42,660	789,164
2027	0	0	(29,084)	733,750	41,865	42,660	789,191
2028	0	0	(29,084)	733,750	41,892	42,660	789,219
2029	0	0	(29,084)	733,750	41,920	42,660	789,247
2030	0	0	(29,084)	733,750	41,949	42,660	789,276
2031	0	0	(29,084)	733,750	41,979	42,660	789,306
2032	0	0	(29,084)	733,750	42,009	42,660	789,336
2033	0	0	(29,084)	733,750	42,040	42,660	789,367
2034	0	0	(29,084)	733,750	42,072	42,660	789,399
2035	0	0	(29,084)	733,750	42,105	42,660	789,432
2036	0	0	(29,084)	733,750	42,139	42,660	789,465
2037	0	0	(29,084)	733,750	42,173	42,660	789,500
2038	0	0	(29,084)	733,750	42,208	42,660	789,535
2039	0	0	(29,084)	733,750	42,244	42,660	789,571
2040	0	0	(29,084)	733,750	42,281	42,660	789,608
2041	0	0	(29,084)	733,750	42,319	42,660	789,646
2042	0	0	(29,084)	733,750	42,358	42,660	789,685
2043	0	0	(29,084)	733,750	42,398	42,660	789,725
Residual	873,817						873,817

( ) = negative.
Source: Asian Development Bank estimates.

F. Sensitivity Analysis

16. Sensitivity analysis examined the impact of changes in costs and benefits and lower growth rates on project economic performance. Estimates of EIRR for the overall project remain above 9% in all tests. The results of the analysis suggest that the economic performance of the overall project is generally robust against identified sources of risk.

Table 2: Economic Viability and Sensitivity Analysis

Sensitivity Test	EIRR (%)	NPV (CNY million)	Sensitivity Indicator	Switching Value (%)[a]
Base case	23.2	3,209		
Increase investment cost by 10%	21.7	3,050	0.64	300
Increase in O&M costs by 10%	23.1	3,192	0.02	1,980
Decrease in benefits by 10%	21.5	2,723	0.72	(66)

Table 2: Economic Viability and Sensitivity Analysis

Sensitivity Test	EIRR (%)	NPV (CNY million)	Sensitivity Indicator	Switching Value (%)[a]
10% increased investment cost, 10% increased O&M, and 10% decreased benefits	20.0	2,546	1.37	

( ) = negative, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance.
[a] Switching value is the percentage increase or decrease in costs or benefits to maintain an EIRR equal to the economic opportunity cost of capital of 9%.
Source: Asian Development Bank estimates.

G. Project Beneficiaries and Poverty Impact

17. **Affordability.** Full cost tariffs for existing wastewater services were estimated to be CNY0.62 per cubic meter. The impact of such a tariff on low-income households was evaluated. The affordability analysis suggests that the affordability of full cost tariffs will not be a problem for low-income households. Expenditures on water and wastewater services with the increased wastewater tariffs never exceed 2% of disposable income; and are well below the 5% benchmark commonly used to assess affordability.

18. **Benefit distribution and poverty impact analysis**. The economic benefits generated from the project will be allocated to stakeholders (Table 3). The distribution of costs and benefits among stakeholders relies on estimates of incremental benefits and the cost generated by the main project outputs. All financial and economic benefits and costs are expressed in present value terms (9% discount rate). The total net benefit is estimated to be CNY3,116 million. Based on the proportion of poor beneficiaries for each project output, the total benefit accruing to the poor is estimated to be CNY899 million and the poverty impact ratio is calculated as 0.20.

Table 3: Benefit Distribution and Poverty Impact Analysis
(CNY million)

	Financial	Economic	Difference	Distribution of Benefits/Costs			
Present Value	1	2	(2)-(1)	Community	Labor	Government	Total
Benefits	4.6	4,855.4	4,850.7	4,850.7			4,850.7
Revenue	4.6						0.0
Intangible benefits		4,855.4	4,855.4	4,855.4			4,855.4
Costs	1,449.0	1,739.4	290.4		21.2	269.1	290.4
Capital	1,198.7	1,442.9	244.2			244.2	244.2
O&M	146.0	171.0	24.9			24.9	24.9
Taxes	0.0	0.0	0.0			0.0	0.0
Unskilled labor	104.2	125.5	21.2		21.2		21.2
Net benefits	(1,444.4)	3,116.0	4,560.4	4,850.7	(21.2)	(269.1)	4,560.4
Proportion of poor				0.2	0.8	0.2	
Net benefits to the poor				970.1	(17.0)	(53.8)	899.3
Poverty impact ratio							0.2

( ) = negative, O&M = operation and maintenance.
Source: Asian Development Bank estimates.