ECONOMIC ANALYSIS

A. Introduction

1. The Zhaotong City Government of Yunnan Province has requested the Asian Development Bank (ADB) funding for the Yunnan Sayu River Basin Rural Water Pollution Management and Eco-Compensation Demonstration Project. The project will demonstrate ADB value addition through the following components: (i) strengthening wastewater management and pollution control with innovative technologies and arrangements; (ii) improving water resources management with innovative information technologies; (iii) establishing an eco-compensation mechanism; and (iv) strengthening education, capacity, and public awareness for water pollution management.

B. Macroeconomic and Sector Context

2. Zhaotong City has one district, one county-level city, and nine counties, out of which one district and all counties are nationally designated poverty areas. Zhaotong has 1,336,700 poor people, the largest poor population in Yunnan. The Sayu River is a tertiary tributary of the Yangtze River. The Sayu River Basin is an important area for ecological protection in the upper Yangtze River Basin. It is the only centralized drinking water source in Zhaotong. Urban drinking water is primarily provided from the Yudong Reservoir, which was constructed in 1998. Water in the Sayu River Basin, including the Yudong Reservoir, is polluted because of (i) waste discharge in the Sayu River Basin, (ii) high sediment runoff into the Sayu River because of soil erosion, and (iii) agriculture-related nonpoint source (NPS) pollution. In many locations of the Sayu River, the water quality is worse than the Class III national standard, which is unfit for drinking.

C. Economic Rationale

3. The project will
   (i) strengthen wastewater management and pollution control in the Sayu River Basin through (a) waste management, (b) solid waste management, (c) pilot eco-villages to reduce emissions, (d) wetland construction to reduce the NPS pollution, (e) afforestation, and (f) promotion of low-emission agriculture;
   (ii) improve water resources management in the Sayu River by (a) constructing ecological embankments, (b) establishing a river protection model using an intelligent cloud platform river information management system in collaboration with the "river chief" system of the People's Republic of China, [1] and (c) establishing a smart water integrated management platform;
   (iii) establish eco-compensation mechanisms to improve financial flows and incentives for conservation and restoration; and
   (iv) strengthen education, capacity, and public awareness for water pollution management.

D. Demand Analysis

4. The demand for new rural wastewater and solid waste management used in the project

[1] The "river chief" system was introduced in the People's Republic of China in 2017. It assigns each part of a river and lake to a certain official.

design is high compared with historical growth rates,[2] which implies that the principal driver of demand growth is increasing per capita demand for service rather than population growth. Rural population projections were set at 0% for the analysis of the benefits of wastewater and solid waste management. The assumed growth of the urban population affects the valuation of water quality benefits. It was conservatively set at one-third of the recent historical rate.

E. Economic Analysis

5. Least-cost and benefit–cost analyses have been conducted following the ADB Guidelines for the Economic Analysis of Projects.[3] Economic analysis was conducted separately for outputs 1 and 2 and for the overall project by comparing scenarios with and without the project.

6. **Output 1: Wastewater management and pollution control in the Sayu River Basin strengthened.** This includes (i) waste management, (ii) solid waste management by introducing garbage pyrolysis facilities, (iii) pilot eco-villages, (iv) wetland construction to reduce the NPS pollution, (v) afforestation, and (vi) the promotion of low-emission agriculture.

7. **Output 2: Water resources management in the Sayu River improved.** This includes (i) the construction of ecological embankments; (ii) the establishment of a river protection model, using an intelligent cloud platform river information management system, in collaboration with the "river chief" system of the People's Republic of China; and (iii) the establishment of a smart water integrated management platform.

8. The economic analysis is based on annual costs and benefits resulting from the output investments. Key features of the analysis include:

(i) economic benefits and costs are based on a domestic price numeraire in first quarter 2019 prices and expressed in yuan (CNY);
(ii) capital costs are based on engineering cost estimates;
(iii) capital costs include physical contingencies of 5%, but not price contingencies or taxes;
(iv) costs and benefits are estimated on a with- and without-project basis;
(v) traded outputs are adjusted to economic prices using a shadow exchange rate factor of 1.023 (non-traded outputs are valued at domestic market prices);
(vi) a shadow wage rate factor of 0.85 is used to convert the wage rate for unskilled labor to an economic opportunity cost of labor;
(vii) the social opportunity cost of capital is assumed to be 6%;[4] and
(viii) costs and benefits are evaluated over 20 years following a 6-year construction period.

F. Least-Cost Analysis

9. Least-cost analysis was completed on subprojects to compare the cost-effectiveness of the subproject design options. Comparisons were based on net present values. The discount rate for all comparisons was 9%. The nonstructural components do not have engineering options to be compared. Least-cost analysis was conducted for engineering options, and the least-cost option for each subproject was selected for the project design.

---

[2] See Detailed Economic Analysis (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President to the Board of Directors), Demand Analysis.
[3] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.
[4] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila. Refer to paras. 16 and 194.

G. Cost–Benefit Analysis

10. **Project costs.** The economic costs include (i) capital costs of works, goods, consulting services, the eco-compensation fund, project preparation, procurement, supervision, and audit; land acquisition and resettlement; ethnic minority development; and education, capacity development, and public awareness raising; and (ii) the cost of operation and maintenance (O&M). Project investment costs are in **Error! Reference source not found.**.

Table 1: Summary of Investment Costs
(CNY'000)

Item	Financial[a]	Economic[b]
Investment Costs		
1. Wastewater management and pollution control in the Sayu River Basin strengthened[c]	725,038	661,699
2. Water resources management in the Sayu River improved[c]	632,360	588,799
3. Eco-compensation mechanism for the Sayu River Basin established	118,056	109,169
4. Education, capacity, public awareness for water pollution management; and project management	139,997	135,318
Total Project Cost	**1,615,451**	**1,494,985**

[a] Financial costs exclude financing charges during implementation.
[b] Economic costs exclude price contingencies and financing charges during implementation.
[c] Cost of the output subject to the economic evaluation.
Source: Asian Development Bank estimates.

11. Estimates of the annual O&M cost during project implementation were obtained from feasibility study reports for the project. The average annual O&M cost for all components is estimated to be 1.1% of the total project investment cost.

12. **Project benefits**. Project benefits are all incremental. The benefits considered in the economic analysis are the following:

(i) **Improved water quality.** The willingness to pay (WTP) of downstream urban residents who depend on the Yudong Reservoir for water supply, estimated based on benefits transfer, is CNY58.0/month.[5] This benefit is apportioned across outputs 1 and 2, which benefit water quality in the Yudong Reservoir.

(ii) **Improved solid waste management.** The WTP for solid waste management, evaluated using a benefits transfer approach, is CNY26.5/month in 2019 prices.[6]

(iii) **Wastewater management.** The average WTP for new wastewater management, determined using a contingent value question in a household survey, is CNY1.22/ton, equivalent to an annual WTP of CNY81. Since respondents are not currently serviced, this value measures the net WTP for improvements; and represents the net benefit or consumer surplus.

(iv) **Improved health.** An analysis has been completed for health benefits for villagers based on the total avoided annual costs of CNY660/household covering health care, productivity, and mortality-related costs.[7] This measure of benefit entails double

[5] H. Wang et al. 2013. Willingness-to-Pay for Water Quality Improvements in Chinese Rivers: An Empirical Test on the Ordering Effects of Multiple-Bounded Discrete Choices. *Journal of Environmental Management*. 131. pp. 256–269.

[6] H. Wang et al. 2011. Municipal Solid Waste Management in Small Towns: An Economic Analysis Conducted in Yunnan, China. *Policy Research Working Paper*. No. 5767. Washington, DC: World Bank.

[7] Water and Sanitation Program. 2012. Economic Assessment of Sanitation Interventions in Yunnan Province, People's Republic of China: A Six-Country Study Conducted in Cambodia, China, Indonesia, Lao PDR, the

counting with the WTP for solid waste and wastewater management since the WTP should reflect the value placed on improved health as well as other benefits, such as convenience and environmental cleanliness. Based on the estimated solid waste and wastewater management benefits per household, only one-third of the households' health benefits are included in the analysis.[8]

(v) **Benefits from new wetlands and forests.** Benefits from investments in wetlands and forests include ecological goods and services other than water quality enhancement. Wetland services are valued at CNY36,669/hectare in 2019 prices.[9] Afforestation benefits are valued at CNY33,264/hectare.[10] Both wetland and afforestation components include agricultural elements since alternative agricultural practices are a primary focus of the subprojects. The unit values above are only applied to the nonagricultural areas.

13. Benefits not accounted for include the crop production revenues from pilot and demonstration activities and the enhancements of village environments.

14. **Economic rates of return.** The net present values and the economic internal rates of return (EIRRs) were calculated for each output using the methods and parameters discussed in para. 8. A summary of results is in **Error! Reference source not found.**. The EIRR for output 1 exceeds the 9% threshold; and the EIRR for output 2, which focuses on instream water quality, exceeds the lower environmental threshold of 6%. The overall EIRR is 10.2%, indicating that the overall project is economically viable. The EIRRs were not calculated for institutional capacity building, as the benefits of these outputs are not quantifiable. Base case cash flows for the overall project are in **Error! Reference source not found.**.

Table 2: Summary of Economic Evaluation

Output	EIRR (%)	NPV (CNY million)
Overall project	10.2	344.74
1. Wastewater management and pollution control in the Sayu River Basin strengthened	12.2	183.33
2. Water resources management in the Sayu River improved	8.1	161.41

EIRR = economic internal rate of return, NPV = net present value.
Source: Asian Development Bank estimates.

Table 3: Economic Internal Rate of Return Analysis for Overall Project
(CNY'000)

Year	Capital Investment	Project Sales Revenues	Non-Capital Costs	Total Economic Benefits	Net Annual Value
2019	(244,798)	0	(3,773)	0	(248,571)
2020	(10,182)	0	(3,706)	0	(13,888)
2021	(205,181)	0	(3,699)	0	(208,880)
2022	(368,464)	0	(3,699)	7,773	(364,390)
2023	(212,110)	0	(17,068)	16,166	(213,011)
2024	(154,259)	0	(17,219)	16,166	(155,312)

Philippines and Vietnam under the Economics of Sanitation Initiative (ESI). Jakarta: World Bank East Asia and the Pacific Regional Office.

[8] See Detailed Economic Analysis (accessible from the list of linked documents in Appendix 2 of the report and recommendation of the President to the Board of Directors), para. 18 and D, Appendix 3.

[9] C. Tong et al. 2007. Ecosystem Service Values and Restoration in the Urban Sanyang Wetland of Wenzhou, China. *Ecological Engineering*. 29 (3). pp. 249–258.

[10] G. Wu. 2009. Measurement on Monetary Value of Forestry Multi-function: A Case of Danzhai County, Guizhou Province, China. *Asian Agricultural Research*. 1 (9). pp. 25–28.

Year	Capital Investment	Project Sales Revenues	Non-Capital Costs	Total Economic Benefits	Net Annual Value
2025	(3,650)	0	(17,636)	100,731	79,444
2026	(968)	0	(17,636)	171,383	152,778
2027	0	0	(17,636)	174,307	156,670
2028	0	0	(17,636)	177,289	159,653
2029	0	0	(17,636)	180,331	162,695
2030	0	0	(17,636)	183,434	165,798
2031	0	0	(17,636)	186,599	168,963
2032	0	0	(17,636)	189,827	172,191
2033	0	0	(17,636)	193,120	175,484
2034	0	0	(17,636)	196,479	178,843
2035	0	0	(17,636)	199,904	182,268
2036	0	0	(17,636)	203,399	185,763
2037	0	0	(17,636)	206,963	189,327
2038	0	0	(17,636)	210,599	192,963
2039	0	0	(17,636)	214,307	196,671
2040	0	0	(17,636)	218,089	200,453
2041	0	0	(17,636)	221,947	204,311
2042	0	0	(17,636)	225,883	208,246
2043	0	0	(17,636)	229,896	212,260
2044	0	0	(17,636)	233,991	216,355
2045	0	0	(17,636)	238,167	220,531
Residual	1,199,612	0	0	0	1,199,612

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

15. **Sensitivity analysis.** Sensitivity analysis was undertaken to test the sensitivity of estimated EIRRs of the proposed outputs to adverse changes in key variables and to confirm their economic viability under unfavorable conditions. Four risks are considered: (i) an increase of 10% in capital cost; (ii) an increase of 10% in the O&M costs; (iii) a 10% decrease in benefits; (iv) a combination of tests (i), (ii), and (iii); and (v) a 10% reduction in urban growth. A summary of sensitivity tests for the overall project is in Table 4. The EIRR exceeds 9% for all tests.

Table 4: Economic Internal Rate of Return and Switching Value

Sensitivity Test	EIRR (%)	NPV (CNY '000)	Sensitivity Indicator	Switching Value (%)
Base case	10.2	344.7		
(i) Increase of 10% in investment cost	9.5	269.1	0.72	18
(ii) Increase of 10% in the O&M costs	10.1	331.2	0.12	105
(iii) Reduction of 10% in benefits	9.3	221.1	0.92	(13)
(iv) Combination of (i), (ii), and (iii)	8.5	131.9	1.70	
(v) Reduction of 10% in growth	10.0	314.7	0.20	(60)

( ) = negative value, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance.
Source: Asian Development Bank estimates.

16. **Benefit distribution and poverty impact analysis.** The economic benefits generated from the project will be allocated to stakeholders. The distribution of costs and benefits among stakeholders relies on the estimates of incremental benefits and costs generated by the main project outputs. All financial and economic benefits and costs are expressed in present value terms (6% discount rate). The total net benefit is estimated to be CNY1,707 million. Based on the proportion of poor beneficiaries for each project output, the total benefit accruing to the poor is estimated to be CNY547 million and the poverty impact ratio is calculated as 0.32.