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. The People's Republic of China (PRC) faces severe challenges regarding management of its national water resources. Many areas suffer critical water shortages during droughts, high economic damage and loss of life during floods, as well as chronic water pollution and widespread degradation of aquatic ecosystems. While floods are not new phenomena in the PRC, the recent rapid economic growth and urbanization have exacerbated flood damages. Flood losses amount to 1%–4% of the gross national product in the PRC, which is 10–20 times greater than losses incurred from flooding in developed countries.

3. Climate change is expected to exacerbate flooding and other climate-related disasters. In the past decade, annual precipitation has increased but the number of rainfall days has fallen in the PRC. Extreme rainstorm events, drought, hail, and flood disasters have become more frequent. Improving watershed management for flood protection and environmental health requires an integrated approach combining structural and nonstructural measures.

4. Responding to the increasing challenges, the PRC has made significant efforts to improve flood management in recent decades by investing in flood control works and multipurpose integrated river basin management, including nonstructural measures such as improved flood management planning, warning, and response. However, such efforts to control water pollution over the last three decades have failed to stop the decline in water quality. The lack of adequate wastewater treatment is a significant contributing factor to this decline. Unsafe drinking water and poor sanitation contribute to health problems for many. In urban and peri-urban areas, poor sanitation leads to poor living conditions.

C. Economic Rationale

5. Alongside the rapid economic growth in the last 30 years, the PRC is facing more frequent and damaging floods together with serious environmental consequences as result of rapid urbanization. Climate variability is likely to increase the frequency and severity of flooding in the PRC, like the one that occurred in July 2016.[2] The Government of the PRC requested ADB to provide lending support to address key water resources management and related issues in Zuoquan County in an integrated manner, including water quality and quantity management, flood mitigation, soil erosion prevention, land use planning, and related capacity building activities.

6. Zuoquan County has a population of 165,042, about 57% of which is rural. As 33% of its population is poor, Zuoquan County is designated a national-level poverty county. It is located on the mountainous east side of Shanxi Province on the upper Qingzhang River, a tributary of the Zhang River. Zuoquan County experiences frequent flooding caused by rapid runoff from its

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[1] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila.
[2] Aon. 2016. *Worst flooding since 1998 leaves $33 bn economic toll in China. Press release*. http://ir.aon.com/about-aon/investor-relations/investor-news/news-release-details/2016/Worst-flooding-since-1998-leaves-33bn-economic-toll-in-China-according-to-Aon-catastrophe-report/default.aspx.

mountainous terrain. The average annual damage resulting from floods in Zuoquan County reaches as high as CNY125 million. Flooding poses a significant risk to residents and constrains sustainable development. The project will prevent flooding in the project area and will reduce annual average flood damage in downstream Zuoquan County by $37.5 million.[3]

7.   Maintaining water quality in Shixia Reservoir is a key issue. Risks include contamination from non-forested areas and loss of existing forests. The Qingzhang River, together with the Shixia Reservoir above the urban area and the Xiajiaozhang Reservoir downstream, is a strategic water source for 1.92 million people in six counties of Shanxi Province. While the Qingzhang River is critical to the entire Zhang River system, underinvestment in water source protection in Zuoquan County has caused continuing deterioration of water quality as result of nonpoint source pollution and soil erosion. Land use around Shixia Reservoir and downstream to Zuoquan County includes farmland, village settlements, and wetlands. Zuoquan County is planning an industrial park and urban expansion in the downstream area of Shixia Reservoir and Qingzhang River. Primary concerns in the urban portion of Zuoquan County, home to 60,000 people, include the protection of water quality from runoff and wastewater, and flood control in urban and downstream areas as urbanization increases storm water runoff.

8.   **ADB's value addition.** The project will adopt integrated river basin management by implementing structural and nonstructural measures in pollution prevention, flood management, ecological conservation and rehabilitation, water demand management, and institutional reform support from upstream to downstream of Qingzhang River. 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 Zuoquan County. The project will introduce innovative sponge city construction design to delay runoff and improve water quality through biofiltration.[4] The project has adopted an integrated urban–rural land use planning and protection approach. Protection measures have been identified according to the characteristics of each land use zone, including vegetation for the areas upstream of the Shixia Reservoir to reduce soil erosion; improvement of the flood protection standard of the Qingzhang River and enhancement of ecological values along the riverbanks; provision of low-impact facilities such as wetland park and enhanced road design; improvement of the urban storm water drainage system, and sewage collection and treatment; and provision of reliable water supply to rural and urban areas, including supply to commercial and industrial customers.

D.   Least-Cost Analysis

9.   Least-cost analysis was conducted for the following alternative engineering options for improving the reservoir spillway gate subcomponent of output 1: (i) removal of rubber dam layout spillway gate, and (ii) removal of existing access bridge layout spillway gate. The net present value (NPV) of option (i) was CNY1,239.7 and the NPV for option (ii) was CNY1,337.5. Hence, option (i) was the least-cost option chosen for the project. Similarly, least-cost analysis was conducted for the following alternative engineering options for the installation of the rural water supply system subcomponent of output 3: (i) industrial and residential water supply layout combined, and (ii) a separate industrial water supply network. The NPV of option (i) was CNY2,604.7 and the NPV for option (ii) was CNY2,495.2. Hence, option (i) was the least-cost option chosen for the project.

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[3] Project preparatory technical assistance consultants' estimates.
[4] The principle of the sponge city is to retain rainwater, filter and clean it naturally, and then slowly discharged into rivers and drain it into the soil.

10.   The major assumptions used for the least-cost analysis are (i) lifetime of the subprojects is 20 years, including a construction period of 5 years; (ii) all prices and costs are expressed in first quarter of 2016 prices; (iii) economic benefits and costs are valued in the domestic price numeraire and expressed in yuan; (iv) physical contingencies of 10% 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 12% per year[5]; and (vii) a shadow exchange rate factor of 0.97 is used to convert the financial prices of nontraded goods to economic prices, while 1.00 is used as the shadow wage factor for skilled labor and 0.80 for unskilled labor.

E.   Cost–Benefit Analysis

11.   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 (Table 2) 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).

12.   **Economic benefits.** The estimated economic benefits comprise four types of quantifiable benefits: (i) improved flood management; (ii) improved water quality management, including improved surface water quality; (iii) improved water supply and wastewater treatment; and (iv) developed urban greenspace, particularly on improved transportation. The present value of the total project economic benefits is CNY910.2 million, broken down by the present value of reduced flood risk (CNY643.0 million), the present value of improved surface water quality (CNY15.3 million), the present value of improved water supply and wastewater treatment (CNY69.5 million), and the present value of improved transportation (CNY182.5 million).

13.   **Economic benefit of improved flood management.** The present value of improved flood management was derived from the present value of avoided flood damage. Project investments for flood management comprise structural improvements for the Shixia Reservoir dam, river embankments, dredging and protection of river channels, and a flood warning system. These works will improve channel capacity to convey flood waters, reduce vulnerabilities in reservoir flood control facilities, and improve the damage-mitigating response to pending floods. The financial value of avoided flood damages was derived from historical flood damage data and estimates of the size of inundation areas associated with floods of varying frequencies. The financial value of historical flood damages was converted to 2016 prices and projected for 20 years after construction (2022–2041) using the real economic growth rate. 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; these were then converted to economic values using the standard conversion factor. The ENPV of improved flood management was derived from the flow of the annualized economic values of flood damages using a 12% discount rate.

14.   **Economic benefit of improved surface water quality.** The present value of improved surface water quality was derived from benefits transfer approach. Wetlands are used to protect water quality as well as to enhance ecological and aesthetic values. Literature values related to

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[5] ADB's *Guidelines for the Economic Analysis of Projects* were revised in March 2017 and require the (i) use of a reduced social discount rate of 9%, and (ii) inclusion of the social benefit of carbon reduction in the economic analysis. The discount rate and carbon reduction were revised after completion of the economic analysis for the project, which was reviewed at the Management review meeting; and the revisions do not affect the conclusions of the economic analysis.

wetland amenity values in the PRC were applied to wetland and forest areas to be developed by the project. The selected value at 2006 prices is CNY36,783 per hectare.[6]

15.   **Economic benefit of improved water supply and wastewater treatment.** The present value of improved water supply was derived from payments made by existing domestic and non-domestic water supply customers. Incremental water supply service improvements will result from providing improved quality and quantity of treated water for domestic and non-domestic users in villages in the north and south districts located east of the urban area of Zuoquan. The resulting willingness-to-pay (WTP) estimates for incremental water supply are CNY1.54 per ton for domestic and CNY1.30 per ton for non-domestic customers.[7] The present value of improved wastewater treatment was derived from the WTP data for domestic wastewater service generated in a household survey. Project investments for wastewater treatment improvement comprise the construction of a wastewater collection network in newly developed urban areas to the west and capacity expansion of a wastewater treatment plant. The resulting WTP estimate for the incremental wastewater treatment service is CNY1.75 per ton.

16.   **Economic benefit of improved transport.** The present value of improved transportation was derived from an avoided cost approach, which estimated savings in vehicle operation costs and the value of reduced travel times. A comprehensive traffic model was developed to estimate the traffic demand from industrial and residential development, traffic diversion caused by development of the road network, public transport, and the increase in car ownership for the main arterial roads of the city. The Road User Costs Knowledge System (RUCKS) model developed by the World Bank was used to complete the analysis of benefits. Vehicle operation costs and travel times were estimated with and without the project, and benefits were estimated as the difference in these. Project investments under output 2 include upgrading of a section of an existing urban arterial road linking the Zuoquan urban area and its new district.[8] The existing four-lane divided road will be expanded to a six-lane road, with a central median and separate lanes for bicycles.

17.   **Economic costs and benefits.** The economic cost comprises investment costs (e.g., civil works, equipment, materials, and land acquisition and resettlement) and operation and maintenance costs (e.g., maintenance and repair, labor, chemicals, utility, and others).[9] As shown in Table 2, the ENPV is CNY457.1 million and the EIRR is 17.9%. 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	Flood Damage	Water Quality	WS and WW	Road	Total
2017	(27,546)	0	0	0	0	0	0	**(27,546)**
2018	(162,462)	0	0	0	0	0	0	**(162,462)**
2019	(213,984)	0	0	0	0	0	0	**(213,984)**
2020	(221,566)	0	120	0	0	0	0	**(221,446)**
2021	(173,300)	0	120	0	0	0	0	**(173,180)**

[6] 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/hectare.

[7] Non-domestic customers include coal industry and mining companies.

[8] Binhe Road.

[9] Project activities are described in the report and recommendation of the President. Capital costs and project operating costs were provided in the feasibility study report prepared on behalf of the project management office by the design institute, in consultation with the implementing agency and the project preparatory technical assistance; and under the guidance of the ADB project officer. Costing was completed using government costing standards; and costing information from site investigations, design institute project files, and queries with suppliers.

Year	Capital Investment	Incremental Sales Revenues	Recurrent Costs	Benefits				Total
				Flood Damage	Water Quality	WS and WW	Road	
2022	0	28,923	(19,380)	35,355	3,602	14,154	28,480	**91,134**
2023	0	38,548	(21,723)	41,883	3,602	15,695	31,340	**109,345**
2024	0	39,592	(21,953)	49,617	3,602	16,047	34,920	**121,824**
2025	0	39,866	(22,057)	58,778	3,602	16,419	38,500	**135,109**
2026	0	40,142	(18,035)	69,632	3,602	16,810	41,230	**153,381**
2027	0	40,318	(22,254)	82,489	3,602	17,049	45,510	**166,714**
2028	0	40,343	(22,288)	97,720	3,602	17,042	53,490	**189,910**
2029	0	40,364	(22,288)	115,764	3,602	17,037	57,840	**212,319**
2030	0	40,381	(22,288)	137,140	3,602	17,032	35,860	**211,727**
2031	0	40,376	(22,288)	162,462	3,602	17,033	37,710	**238,895**
2032	0	40,365	(29,868)	192,461	3,602	17,034	43,970	**267,563**
2033	0	40,355	(22,288)	227,998	3,602	17,034	47,300	**314,001**
2034	0	40,344	(22,288)	270,097	3,602	17,035	50,490	**359,280**
2035	0	40,334	(22,288)	319,970	3,602	17,036	57,900	**416,553**
2036	0	40,323	(18,158)	379,052	3,602	17,036	58,720	**480,576**
2037	0	40,313	(22,288)	449,043	3,602	17,037	62,290	**549,997**
2038	0	40,303	(22,288)	531,958	3,602	17,038	65,570	**636,182**
2039	0	40,293	(22,288)	630,183	3,602	17,038	69,070	**737,898**
2040	0	40,283	(22,288)	746,544	3,602	17,039	69,070	**854,250**
2041	0	40,273	(22,288)	884,392	3,602	17,040	69,070	**992,089**
Residual	286,379							**286,379**

( ) = negative value, WS = water supply, WW = wastewater treatment.
Source: Asian Development Bank estimates.

F. Sensitivity Analysis

18. Sensitivity analysis was carried out to assess the economic viability of the project in different adverse scenarios: (i) a 10% increase in capital cost, (ii) a 10% increase in operation and maintenance costs, (iii) a 10% decrease in benefits, and (iv) a combination of the scenarios. Sensitivity indicators and switching values were calculated. The results of this analysis (Table 2) indicate that the project economic viability is robust against these adverse scenarios, while it showed greatest sensitivity to changes in investment costs and benefits.

Table 2: Economic Viability and Sensitivity Analysis

Sensitivity Test	EIRR	NPV (CNY million)	Sensitivity Indicator	Switching Value
Base case	17.9%	457.1		
10% increase in capital cost	16.8%	403.4	0.58	80%
10% increase in O&M costs	17.8%	447.9	0.07	480%
10% decrease in benefits	16.8%	457.1	0.58	(48%)
10% increase in costs, 10% decrease in benefits	15.7%	394.1	1.21	

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

G. Project Beneficiaries and Poverty Impact

19. The economic benefits generated from the project will be allocated to stakeholders. The distribution of costs and benefits among stakeholders relies on 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 (12% discount rate). The total net benefit is estimated to be CNY1,079.4 million. Based on the proportion of poor beneficiaries, the total benefit accruing to the poor is estimated to be CNY112.5 million; and the poverty impact ratio is calculated as 0.25.