ECONOMIC ANALYSIS

A. Introduction

1. The economic analysis of Yunnan Chuxiong Urban Environment Improvement Project covers the subprojects in each of the three project cities in Chuxiong Municipality, Lufeng County and Wuding County. The subprojects each have flood management, road, and solid waste management components. The analysis has been carried out to determine whether the benefits expected to be generated by the project are sufficient to cover the cost of investments in each subproject and in the project as a whole. Economic viability has been evaluated on this basis.

2. The project's economic viability was assessed through a least-cost analysis and a standard cost–benefit analysis. The least-cost analysis of alternative options examined whether options chosen for the project represent the least-cost means of meeting the project objectives and the forecast 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] These provide the basis for calculating the economic internal rate of return (EIRR) for each of the three subprojects and the project as a whole.

B. Project Alternatives and Least-Cost Analysis

3. The least-cost analysis compared economic costs of technically, environmentally, and socially viable project options and selected the one with the lowest present value of economic costs. Analysis of the flood management component adopted cost-effective engineering design options for river dike structures, cross-sections, and landscaping and for river training works (e.g., dredging or nondredging options). Better protection and enhancement of the river environments was emphasized. The options for the river training works included maintaining a natural river flow, avoiding vertical retaining walls, and using gabions and pre-stressed concrete blocks with gravel as slope protection materials. For the project's road component, cost-effectiveness analysis emphasized pedestrian-and-nonmotorized-vehicle-friendly cross-section designs; the selection of the most efficient alternative routes and road pavement materials in terms of initial cost, operation and maintenance (O&M) cost; and the function of the roads.

C. Cost and Benefit Analysis

1. Economic Costs

4. Economic costs included (i) the capital cost, including those for land acquisition, resettlement, and environmental mitigation and monitoring; (ii) the cost for capacity development and institutional strengthening; (iii) physical contingency costs; and (iv) O&M costs, including the replacement cost of depreciated equipment. Economic costs were valued in local currency using the domestic prices and expressed in economic terms using the domestic price numéraire at constant 2013 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 unskilled labor, estimated at 0.80. The land acquisition and resettlement costs were

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

estimated based on their opportunity costs—i.e., the costs of agricultural output foregone and the relocation of displaced activities. Transfer payments, including taxes, duties, and interest, were excluded from the economic costs.

2. Economic Benefits

5. Chuxiong Municipality, Lufeng County and Wuding County subprojects will involve investments in flood management, roads and related urban infrastructure, and solid waste management. Flood management and control activities will comprise environmentally friendly river rehabilitation, including construction of flood dikes, slope protection, and landscaping; and installation of a flood early warning system. The three subprojects will construct urban road networks that will include additional infrastructure and landscaping to promote environmentally friendly urban development. Each subproject will improve urban sanitary conditions and reduce public health risks caused by poor solid waste handling. Paras. 6–10 summarize the estimated economic benefits in the three sectors.

6. **Flood management**. Frequent small floods affect the subproject areas every year. The estimated economic losses from recent large floods include CNY66.5 million in 2003 in Chuxiong Municipality, CNY53.9 million in 2003 in Lufeng County, and CNY84.8 million in 1998 in Wuding County. The project will raise the flood control standards in the subproject areas to once-in-20- or once-in-50-years by providing integrated flood protection, improved river embankments, drought management, soil erosion control, and river ecosystem protection. It will also strengthen emergency preparedness and response by installing flood monitoring and early warning systems and providing capacity building. The final engineering design included ecological restoration and protection of the river and its habitats. The flood management activities will also enhance public access to the riverfront and create a pleasant urban environment and public space for local residents by providing public paths and landscaping. The expected economic benefits from flood management include (i) the avoidance of physical and nonphysical damage through the prevention of frequent flooding, (ii) increased investment opportunities in the areas where the flood risk will be reduced, (iii) the recreation and ecological value to residents of the amenities to enhance public access to the river and improve the waterside environment. Since land value appreciation and amenity benefits were difficult to quantify due to lack of data, the analysis quantified avoided economic losses to estimate the economic benefits.

7. The benefits of river flood management were evaluated by avoided flood damage and its economic losses. Based on the historical data, the past economic losses by floods with 5-year, 10-year, 20-year, and 50-year return periods were estimated in the current economic value. Without the project, the value of damage due to flooding was assumed to increase with the urban growth and industrial development expected to occur in the project areas. An adjustment was made to account for the increase in the value of assets in the project areas due to economic growth, using the average annual economic growth rate in Chuxiong Municipality, Lufeng County and Wuding County during 2003–2013. The annual value of damage avoided was estimated using triangulation for floods, with return periods between 5–10 years, 11–20 years, 21–50 years, and 51–100 years. The estimates of the economic losses avoided from the floods prevented were based on the area protected by the proposed project.

8. Amenity values can be calculated by estimating the willingness-to-pay (WTP) of residents near the riverside improvements areas and of other visitors to the areas. In the People's Republic of China, there was a case that used contingent valuation method to estimate the residents' WTP for and/or willingness-to-accept the amenity benefits of the river

rehabilitation.[3,4] However, due to the lack of local survey data, amenity value was not considered for the analysis.

9. **Road and related urban infrastructure**. The benefit estimates for the subproject road components depended on future transport demand in the areas. The demand forecasts were simulated and calibrated using existing traffic data in the three project cities. By modifying the number of trips generated and attracted by each area, average daily intensities were simulated for with-project and without-project scenarios on each route. The analysis considered four types of benefits: savings in vehicle operating costs; reduction in road accident; savings in travel time; and beneficial impacts on local economies, measured by additional gross domestic product growth. For with- and without-project scenarios, average fuel consumption per kilometer at the various travel speeds on the project roads was estimated using the national data. Avoided road accident costs for the with-project and without-project scenarios were computed as a function of total distance travelled.[5] To convert travel time savings by absolute time values into monetary units, an appropriate value for travel time savings was chosen, based on a review of the literature.[6] Key networks were designed for with-project and without-project scenarios for the traffic forecast model. Projections of traffic volumes on project roads and related existing roads were based on projected socioeconomic development and traffic demand. The enhanced traffic forecast for 20 years was used for the with-project project and without-project scenarios, covering cars, buses, and trucks. Project-induced traffic was estimated and included. Traffic accident statistics on injuries and deaths during 2001–2010 were considered. They showed that annual number of injuries and deaths ranged 7–26, with a median value of 17. Property damage was limited, and the 2010 value was merely CNY265,700.

10. **Solid waste management**. The economic benefits of the solid waste management components of the three subprojects were estimated based on the expected improvements in sanitation on urban streets, in the river and on the riverside, and in other areas where the dumping of solid wastes now seriously degrades the urban environment. The average WTP of urban residents in Xi'an for reduced solid waste was CNY11.6 per month and this WTP was applied to calculate the benefits of solid waste management.[7] Only the residents living near the dumping sites will be directly affected, and the analysis assumed that 5% of the population in each city of Chuxiong Municipality, Lufeng County and Wuding County would benefit.

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[3] J. Ban et al. 2011. Valuation of Non-Use Values of Yangtze River in Nanjing. *Environmental Protection Science*. 37 (4). pp. 17–50; W. Li et al. 2012. Public Preferences for Shanghai Riparian Zone and Evaluation of Its Ecosystem Service Value, *China Demography, Resource and Environment*, 22(6): 147-151; L. Jin and J. Guo. 2010. *A Comparative Study of the Urban and Rural Residents' WTP for Environmental Protection: A Case Study at the Nanbanhe Watershed in Yunnan,* Journal of Yunnan Normal University, 42(4): 53-58.

[4] Based on the literature (footnote 3), the estimated benefits under the project may range from CNY12.6 million in Wuding County to CNY74.0 million in Chuxiong Municipality.

[5] Theoretically, this benefit can be negative in net. Although improving road infrastructure reduces the number of accidents that will take place, it also increases the average driving speed, thus raising the probability of death in each accident.

[6] D. Hensher. 1997. Behavioral Value of Travel Time Savings in Personal and Commercial Automobile Travel. In D. Greene, D. Jones, D. Delucchi, and W. Mark. eds. *The Full Costs and Benefits of Transportation: Contributions to Theory, Method and Measurement*, Heidelberg and New York, Springer, 245-79; J. Calfee and C. Winston. 1998. The Value of Automobile Travel Time: Implications for Congestion Policy, *Journal of Public Economics*. 69. pp. 83–102; M. Wardman. 1998. The Value of Travel Time. *Journal of Transport Economics and Policy*. 32 (3). pp. 285–316.

[7] S. Zhan and H. Zhang. 2012. Awareness of categorized solid waste collection and WTP survey: The case of Xi'an. *Urban Issues*. 4. pp. 57–62. The figure was considered applicable because local people's average income of the project benefitted areas of Chuxiong Municipality, Lufeng County and Wuding County are similar to the areas studied in Xi'an.

3. Economic Internal Rate of Return

11. The calculations for the base case economic internal rate of return (EIRR) for the entire project are in Tables 1 and 2. At a 12.0% discount rate, the project is economically viable. The overall project EIRR was estimated to be 15.3%. This was based on EIRRs of 16.1% for the Chuxiong subproject, 12.7% for the Lufeng subproject, and 17.4% for the Wuding subproject. The benefit estimates can be considered conservative because the qualitative benefits of improved sanitation in villages, that will no longer be affected by inflows of untreated wastewater, are not included. Neither are the returns to be realized from amenity benefits for the improved public access to the riverside and reduced disruptions of economic activities to be achieved by the project's prevention of frequent flood events.

12. The sensitivity analysis tested the effects of negative changes in the key parameters that determine the benefits and costs of the project. This analysis found that the project would remain economically viable in the face of a 10.0% decrease in benefits, with an EIRR of 14.0%; a 10.0% increase in capital cost (EIRR of 14.2%); and a 1-year implementation delay (EIRR of 14.9%). The project's overall economic internal rate of return would drop to 12.5% under the combined impacts scenario. The switching value analysis indicated that the project would be economically viable until the benefits decrease by 24% or the capital cost increases by 33%. Neither is likely to happen.

Table 1: Summary of the Economic Internal Rate of Return and Sensitivity Analysis for Flood Management Component

Scenario	EIRR (%)	NPV (CNY million)	Sensitivity Indicator	Switching Value
(i) Base case	15.3	386.6		
(ii) Benefits decreased by 10%	14.0	227.1	4.1	24.2
(iii) Capital cost increased by 10%	14.2	270.8	3.0	33.4
(iv) Construction delay of 1 year	14.9	325.0		
(v) Combination of ii, iii, and iv	12.5	58.2		

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

Table 2: Overall Project Economic Internal Rate of Return
(CNY million)

	Benefits				Costs							
Year	Chuxiong	Lufeng	Wuding	Total	Capital Costs	O&M	Total	Net Benefits	Benefit Decline of 10%	Capital Cost Overrun of 10%	1-Year Delay	Combined
2014	0.0	0.0	0.0	0.0	20.3	0.0	20.3	(20.3)	(20.3)	(22.3)	0.0	0.0
2015	0.0	0.0	0.0	0.0	168.3	0.0	168.3	(168.3)	(168.3)	(185.2)	(20.3)	(22.3)
2016	1.1	0.0	0.1	1.2	378.8	0.0	378.8	(377.6)	(377.7)	(415.4)	(168.3)	(185.2)
2017	1.3	0.4	0.3	2.0	694.4	0.0	694.4	(692.4)	(692.6)	(761.9)	(377.6)	(415.6)
2018	1.6	0.4	0.2	2.3	685.4	0.0	685.4	(683.1)	(683.3)	(751.7)	(692.4)	(762.1)
2019	85.2	78.2	57.4	220.7	0.0	10.6	10.6	210.1	188.0	210.1	(683.1)	(751.9)
2020	93.9	85.6	63.0	242.6	0.0	10.7	10.7	231.9	207.6	231.9	210.1	186.9
2021	103.3	93.9	69.3	266.4	0.0	10.8	10.8	255.6	229.0	255.6	231.9	206.6
2022	113.6	102.8	76.2	292.6	0.0	10.9	10.9	281.7	252.4	281.7	255.6	227.9
2023	122.9	111.1	82.4	316.4	0.0	25.6	25.6	290.8	259.2	290.8	281.7	251.3
2024	133.1	120.1	89.2	342.4	0.0	11.0	11.0	331.4	297.1	331.4	290.8	256.6

	Benefits				Costs							
Year	Chuxiong	Lufeng	Wuding	Total	Capital Costs	O&M	Total	Net Benefits	Benefit Decline of 10%	Capital Cost Overrun of 10%	1-Year Delay	Combined
2025	144.2	132.8	99.5	376.5	0.0	11.1	11.1	365.4	327.7	365.4	331.4	296.0
2026	156.4	140.6	104.7	401.7	0.0	11.3	11.3	390.4	350.3	390.4	365.4	326.6
2027	169.7	152.3	113.5	435.5	0.0	11.4	11.4	424.1	380.6	424.1	390.4	349.1
2028	184.3	165.0	123.2	472.5	0.0	48.4	48.4	424.1	376.9	424.1	424.1	379.5
2029	200.3	179.4	134.2	513.9	0.0	11.5	11.5	502.4	451.0	502.4	424.1	372.0
2030	217.9	194.1	145.3	557.3	0.0	11.6	11.6	545.7	489.9	545.7	502.4	449.9
2031	237.2	210.7	158.0	605.8	0.0	11.7	11.7	594.1	533.5	594.1	545.7	488.8
2032	258.3	228.9	171.9	659.0	0.0	11.9	11.9	647.2	581.3	647.2	594.1	532.3
2033	281.6	248.7	187.1	717.4	0.0	30.5	30.5	687.0	615.2	687.0	647.2	580.1
2034	307.2	270.5	203.8	781.5	0.0	12.0	12.0	769.5	691.3	769.5	687.0	612.2
2035	335.4	295.3	223.2	853.9	0.0	12.1	12.1	841.7	756.3	841.7	769.5	690.1
2036	366.4	322.4	244.4	933.2	0.0	12.3	12.3	920.9	827.6	920.9	841.7	755.1
2037	400.6	352.1	267.6	1,020.3	0.0	12.4	12.4	1,007.8	905.8	1,007.8	920.9	826.4
2038	435.4	382.4	291.0	1,108.8	0.0	12.6	12.6	1,096.2	985.4	1,096.2	1,007.8	904.6
NPV at 12%								**386.6**	**227.1**	**270.8**	**325.0**	**58.2**
EIRR								**15.3%**	**14.0%**	**14.2%**	**14.9%**	**12.5%**

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