ECONOMIC ANALYSIS

1. The technical assistance consultants carried out economic analyses for the two water supply subprojects and four wastewater and sanitation subprojects. The analyses were undertaken in accordance with the *Framework for the Economic and Financial Appraisal of Urban Development Sector Projects*, *Guidelines for the Economic Analysis of Projects,* and *Guidelines for the Economic Analysis of Water Supply Projects* of the Asian Development Bank (ADB).[1]

A. Methodology and Assumptions

2. The evaluation was conducted through a comparison of the without-project and with-project scenarios. The assumptions used in the evaluation were as follows:

i. Economic analyses and the calculation of the economic internal rate of return (EIRR) were undertaken at constant 2017 prices; the domestic price numeraire was adopted in the analysis.

ii. An exchange rate of KR4,000 per $1.00 was used.

iii. The investment and operations and maintenance (O&M) costs were based on reviewed estimates from the Cities Development Initiatives for Asia technical assistance study.[2]

iv. The financial values were converted to their economic values using the appropriate conversion factors: tradable goods were converted using the shadow exchange rate factor of 1.10 and a shadow wage rate factor of 0.75 for rural unskilled labor was applied.[3] Transfer payments such as taxes, duties, and subsidies were excluded in the economic analysis.

v. The economic life of each subproject is assumed to be 25 years; the subprojects' vehicles and equipment are assumed to be replaced every tenth year.

vi. A 9% economic opportunity cost of capital is assumed.

B. Without Project and With Project Situations

3. **Battambang water supply**. The total combined capacity of the two existing water treatment plants is 33,520 cubic meters per day (m^3/day). The existing distribution network is 374 kilometers (km) with a coverage area of 5,603 hectares (ha). The number of service connections as of February 2017 is 14,249 or about 31% of the population. Without project household use is 60 liters per capita per day (lcd) and 140 lcd by 2040 with the project. [4]

4. The subproject will provide (i) a water treatment plant (WTP) with a capacity of 50,000 m^3/day and four booster pumps; (ii) raw water intake with four pumps and a raw water pipeline of 6.6 km; (iii) 109 km of distribution pipeline; and (iv) an office, pump station, and

[1] ADB. 1994. *Framework for the Economic and Financial Appraisal of Urban Development Sector Projects*. Manila; ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila; ADB. 1998. *Guidelines for the Economic Analysis of Water Supply Projects*. Manila.

[2] ADB. 2013. *Regional Technical Assistance on supporting the Cities Development Initiatives for Asia.* Manila.

[3] The economic conversion factors are identical to those used in the ADB-financed Cambodia project: ADB. 2014. *Report and Recommendation of the President to the Board, Proposed Loan, Kingdom of Cambodia, Urban Water Supply Project*. Manila

[4] Refer to supplementary appendix 23 "Complete Economic and Financial Analysis".

chemical building. The subproject is expected to increase access to safe piped water to more than 90% of the population by 2022.

5. **Kampong Cham water supply**. The total combined capacity of the two existing WTPs is 19,500 m^3/day. The existing distribution network is 166.5 km with a coverage area of 4,311 ha. The number of service connections as of February 2017 is 7,371 with a served population of about 37%. Without project household use is 60 lcd and 145 lcd by 2040 with the project.

6. The subproject will provide (i) a WTP with a capacity of 11,600 m^3/day and three booster pumps; (ii) raw water intake with three pumps and a raw water pipeline of 4 km; (iii) 52 km of distribution pipeline with three booster pumps along the network; and (iv) a service and workshop building. The subproject is expected to increase access to safe piped water to more than 90% of the population by 2022.

7. **Battambang wastewater and sanitation**. The existing wastewater treatment plant (WWTP), which was originally designed for 1,000 m^3/day and to serve 3,125 households, currently operates at 450 m^3/day serving only 1,400 households. The sewerage and drainage network is a combined system. As of month year, all other wastewater flows to several open canals that drain into the river and rice fields to the north of the town. DPWT does not have a vacuum truck for septage desludging. Seven private vacuum trucks are operating but septage is disposed to rice fields without treatment. There is limited awareness of sanitation. There are no regulations on septic tank cleaning and proper disposal of sludge. Service coverage with the project will be 99% by 2030, up from 18% without the project.

8. The subproject will provide (i) a WWTP with a total capacity of 10,625 m^3/day in a new site; (ii) sludge drying beds; (iii) solar aerators with hoses; (iv) wastewater mains, pumping mains, and trunk sewers for a separated system; (v) a compact excavator, a 6 m^3 vacuum truck, sludge dewatering container, portable sludge pumps, and water quality testing equipment; (vi) septage disposal bay with concrete apron and service water for cleaning; (vii) pumps and pump stations and/or pump wells; (viii) household connections; and (ix) site office, storeroom, and carpark. The project will provide free household connections to ensure that all households will use the facilities. Served population by 2023 will increase by 47,320 persons (8,700 households). The project will also include decommissioning of the existing WWTP lagoon site. The project will conduct an extensive awareness campaign on sanitation. Licensing of private vacuum trucks and regulations on septic tank cleaning and proper disposal of sludge will be implemented.

9. **Sihanoukville wastewater and sanitation**. The existing WWTP has a capacity of 6,900 m^3/day. Originally, the intention was that 5,900 m^3/day would serve 3,368 households and the balance of 1,000 m^3/day would be for the effluent of the Cambrew factory. In reality, an approximate volume of 3,000 m^3/day is used for 1,767 households (52% of the original target) and the balance of 3,900 m^3/day is used for Cambrew. Forty-eight percent of the originally targeted households did not want to connect to the system. There are no pump stations. At [month] [year], one anaerobic pond is full of sludge and the other three ponds are half full. There are only two vacuum trucks (one owned by the DPWT and one owned by a private operator) for the relatively large population and number of hotels. The community has limited awareness of sanitation. There are no regulations on septic tank cleaning and proper disposal of sludge. Service coverage with the project will be 78% by 2030, up from 17% without the project.

10. The subproject will undertake or provide the following: (i) upgrade the existing WWTP capacity to 20,500 m^3/day through mixing and/or aeration; (ii) remove sludge from the four anaerobic lagoons; (iii) sludge disposal to a landfill; (iii) solar aerators with hoses; (iv) wastewater

mains, pumping mains, and trunk sewers; (v) compact excavator, 6 m^3 vacuum truck, sludge dewatering container, potable sludge pumps and water quality testing equipment; (vi) septage disposal bay with concrete apron and service water for cleaning; (vii) pumps and pump stations and/or pump wells; (viii) household connections; and (ix) shaded storage for sludge pumps, excavator, and vacuum truck. The project will provide free household connections, including to those not connected in the existing service area, to ensure that all households will use the facilities. Served population by 2023 is estimated to increase to 43,680 persons (8,000 households). The project will conduct an extensive awareness campaign on sanitation. Licensing of private vacuum trucks and regulations on septic tank cleaning and disposal of sludge will be implemented.

11. **Kampong Cham sanitation**. There is no reticulated wastewater collection system in Kampong Cham. Wastewater runs to the Mekong through a series of combined road drains. The city center has an unknown number of working septic; a small number of private vacuum trucks empty these septic tanks on demand and—since there is no septage treatment facility—dispose the sludge into surrounding agricultural land. There is limited community awareness of sanitation. There are no regulations on septic tank cleaning and proper disposal of sludge. Service coverage with the project will be 9% by 2030, up from 0% without the project.

12. The subproject will provide (i) a septage treatment facility, (ii) a compact excavator, (iii) one 6 m^3 vacuum truck, and (iv) a sludge dewatering container. The project will conduct an extensive awareness campaign on sanitation. Licensing of private vacuum trucks and regulations on septic tank cleaning and proper disposal of sludge will be undertaken.

13. **Siem Reap wastewater**. The design and installation of the interceptor sewer were completed under the under the ADB Mekong Tourism Development Project, with construction from 2007 to 2009 and commissioning in 2010.[5] Between 2011 and 2014, the pipeline collapsed and failed in five locations. Three of these collapse locations have been fully repaired, the upstream deformity has had a temporary repair and backfill, and the fifth failure point around 500m upstream of the pump station has not been repaired due to lack of budget. The pipe remains blocked at this location. The interceptor sewer stopped functioning in [month year]. In addition, it also has insufficient hydraulic capacity. Failure along any part of this pipe means that there is no way for wastewater to reach the WWTP, and all of it is discharged via overflow to the town's drainage. Coverage remains at 55% with the project.

14. The subproject will replace the failed interceptor sewer with the least-cost option. Two options were analyzed: (i) the same deep alignment as existing using trenchless technology with 1000mm diameter pipes; and (ii) a shallower alignment with 3–4 in-line pump stations, using open cut trenching for 1000mm diameter pipes. A third option (same deep alignment as existing using open cut trenching for 1000mm diameter pipes) was discounted due to the problems experienced on the original project with dewatering, operating in a deep trench, necessary road closures, disruption, and mess in the main tourist area.

C. Economic Benefits

15. The parameters used in quantifying the economic benefits are presented in a supplementary document (footnote 4).

[5] ADB. 2002. *Report and Recommendation of the President to the Board of Directors, Proposed Loans to the Kingdom of Cambodia, Lao People's Democratic Republic and Socialist Republic of Vietnam for the Greater Mekong Subregion Mekong Tourism Development Project*. Manila.

16. **Water supply.** The economic benefits of the water supply subprojects were quantified based on the following:

i. Resource cost savings associated with the replacement of non-incremental water consumed, previously obtained from alternative non-piped water sources with those from the new piped water supply system. This is valued in terms of the weighted average supply price from existing non-piped water sources.[6]

ii. Consumer surplus, reflected in the incremental water consumed and billed, measured as the difference between with and without project per capita consumption.[7] This is valued at the average demand price of water (the average of the weighted average supply price from existing non-piped water sources and the average tariff).[8]

17. **Wastewater and sanitation**. The economic benefits for the wastewater and sanitation subprojects were quantified in terms of health benefits. The health benefits were measured using the disability-adjusted-life-year (DALY) approach.[9] The DALY approach measures overall disease burden and expresses it as the number of years lost due to ill health, disability, or early death.[10] The World Health Organization (WHO) estimated the total DALYs in Cambodia at 38,451 per 100,000 population.[11] The WHO also estimated that 10% of the total DALYs in Cambodia were related to water, sanitation, and hygiene issues.[12] Following the WHO approach, the analysis calculated the annual economic value of a DALY as equivalent to the country's per capita gross national income (GNI) in a given year.[13] The country's estimated per capita GNI in 2015 was US$3,300, based on purchasing power parity.[14] Real GNI growth was assumed at 2% per annum. Savings in DALYs attributable to the subprojects were assumed at 50% for the Battambang and Sihanoukville wastewater and sanitation subprojects and 20% for the Kampong Cham sanitation subproject of the calculated economic value of DALYs.

D. Results of Economic Evaluation

18. **Economic evaluation.** The results of the economic and sensitivity analysis are summarized in the table below. The subprojects are economically viable in the base case scenario and robust against downside risks. The subprojects' economic performances are most sensitive to benefits delay and reduction, but the performances remain above the required threshold levels (KR0 for net present value, 9% for economic internal rate of return).

[6] Weighted average supply price from existing non-piped water sources is about KR11,688/m^3 in Battambang and KR12,276/m^3 in Kampong Cham.

[7] Per capita consumption without project is assumed at 60 liters per capita per day (lcd) and with project at 140 lcd in Battambang and 145 lcd in Kampong Cham.

[8] ADB. 1999. *Handbook for the Economic Analysis of Water Supply Projects*. Manila (p. 146).

[9] The approach was developed by Harvard University for the World Bank in 1990 for a study that provided a comprehensive assessment of mortality and disability from diseases, injuries and risk factors. The World Health Organization (WHO) adopted the method in 1996. DALY determination is continually revised by the WHO.

[10] A DALY is an indicator of life expectancy combining mortality and morbidity into one summary measure of population health to account for the number of years lived in less than optimum health.

[11] World Health Organization. 2004. *World Health Report.* Geneva.

[12] WHO. 2007. *Environmental Burden of Disease Series No. 15 (Water, Sanitation and Hygiene)*. Geneva.

[13] The WHO Commission of Macroeconomics and Health assumes that each DALY can be valued at one year of per capita GNI to arrive at a conservative estimate of the economic value of a DALY.

[14] World Bank. 2015. *World Development Indicators*. Washington D.C.

Economic Evaluation Results and Sensitivity Analysis

Scenario	Change	NPV [a] (KR million)	EIRR (%)	SI [b]	SV [c]
BTB WS					
Base Case		215,653	18.91%		
Increase in Capital Costs	+ 10%	204,952	17.91%	1.01	99%
Increase in O&M Costs	+ 10%	210,320	18.73%	0.18	561%
Decrease in Benefits	- 10%	178,053	17.62%	1.30	77%
Benefits Delay	1 year	175,183	16.88%	NPV lower by	19%
KPC WS					
Base Case		40,417	15.08%		
Increase in Capital Costs	+ 10%	36,584	14.20%	1.44	69%
Increase in O&M Costs	+ 10%	39,269	14.94%	0.23	444%
Decrease in Benefits	- 10%	31,393	13.96%	1.84	54%
Benefits Delay	1 year	30,703	13.56%	NPV lower by	24%
BTB WW					
Base Case		75,142	27.92%		
Increase in Capital Costs	+ 10%	72,011	25.81%	1.12	90%
Increase in O&M Costs	+ 10%	74,839	27.84%	0.04	2479%
Decrease in Benefits	- 10%	64,193	25.52%	1.27	79%
Benefits Delay	1 year	63,910	23.27%	NPV lower by	15%
SHV WW					
Base Case		46,998	20.48%		
Increase in Capital Costs	+ 10%	43,202	18.78%	1.48	68%
Increase in O&M Costs	+ 10%	46,514	20.38%	0.09	1086%
Decrease in Benefits	- 10%	38,018	18.50%	1.72	58%
Benefits Delay	1 year	38,044	17.42%	NPV lower by	19%
KPC SAN					
Base Case		2,007	19.05%		
Increase in Capital Costs	+ 10%	1,785	17.34%	1.71	59%
Increase in O&M Costs	+ 10%	1,944	18.76%	0.30	338%
Decrease in Benefits	- 10%	1,521	16.85%	2.19	46%
Benefits Delay	1 year	1,531	15.89%	NPV lower by	24%
SRP WW					
Base Case		5,682	10.02%		
Increase in Capital Costs	+ 10%	960	9.16%	8.42	12%
Increase in O&M Costs	+ 10%	5,611	10.01%	0.12	808%
Decrease in Benefits	- 10%	320	9.06%	9.42	11%
Benefits Delay	1 year	105	9.02%	NPV lower by	98%

BTB WS = Battambang water supply; BTB WW = Battambang wastewater and sanitation; KPC SAN = Kampong Cham sanitation; KPC WS = Kampong Cham water supply; SHV = Sihanoukville wastewater and sanitation; SRP WW = Siem Reap wastewater.

[a] NPV = Net Present Value discounted at EOCC of 9%

[b] SI = Sensitivity Indicator (ratio of % change in EIRR above the cut-off rate of 9% to % change in a variable)

[c] SV = Switching Value (% change in a variable to reduce the EIRR to the cut-off rate of 9%)

Source: Asian Development Bank.

19. **Project sustainability**. The subprojects' sustainability is highly dependent on the implementation of the tariff, regular fee adjustments, and the connection of prospective customers. Providing free connections for sewerage and implementing an easy installment or subsidy scheme for water connections similar to that of the Phnom Penh Water Supply Authority will ensure a high connection rate.

20. **Distribution and poverty impact analysis.** An assessment of the distribution of benefits and costs for the water supply and sanitation investments indicates a poverty impact ratio ranging from 28.92% to 32.37%. According to the 2015 updated commune databases, the poverty rate in the subproject towns ranges from 14.02% to 23.16%.