

DETAILED ECONOMIC ANALYSIS

This appendix presents in greater detail the assumptions on population and service coverage growth, and the cost-benefit analyses of the subprojects that make up Tranche 3 of the Ulaanbaatar Urban Services and *Ger* Areas Development Investment Program.

Table 1: Projected Key Variables

Year	Sharkhad base figures			Tolgoit base figures			Service/ beneficiary coverage	DALY economic value
	Population	Households	Businesses	Population	Households	Businesses		
2019	9,046	2,114		6,979	1,642			3,913
2020	9,634	2,251		7,433	1,749			4,107
2021	10,289	2,404		7,938	1,868			3,984
2022	10,999	2,570		8,486	1,997			3,904
2023	11,780	2,752		9,088	2,138		3.8%	4,287
2024	12,640	2,953	132	9,752	2,295	103	7.5%	4,814
2025	13,588	3,175	139	10,483	2,467	108	15.0%	5,527
2026	14,621	3,416	146	11,280	2,654	113	28.0%	5,897
2027	15,761	3,682	153	12,160	2,861	119	41.0%	6,251
2028	17,006	3,973	161	13,120	3,087	125	54.0%	6,624
2029	18,350	4,287	169	14,157	3,331	131	67.0%	7,020
2030	19,818	4,630	177	15,289	3,597	138	80.0%	7,439
2031	21,304	4,978	188	16,436	3,867	149	80.0%	7,883
2032	22,795	5,326	203	17,586	4,138	161	80.0%	8,353
2033	24,277	5,672	219	18,730	4,407	174	80.0%	8,852
2034	25,733	6,012	237	19,853	4,671	188	80.0%	9,380
2035	27,149	6,343	256	20,945	4,928	203	80.0%	9,940
2036	28,506	6,660	276	21,993	5,175	223	80.0%	10,534
2037	29,789	6,960	298	22,982	5,408	245	80.0%	11,163
2038	30,981	7,238	322	23,902	5,624	270	80.0%	11,829
2039	32,065	7,492	348	24,738	5,821	297	80.0%	12,535
2040	33,027	7,717	376	25,480	5,995	326	80.0%	13,284

DALY = disability-adjusted life-year.

Note: Service coverage for 2023 applied to sewerage and heating subprojects only.

Source: Asian Development Bank estimates.

Table 2: Urban Road Improvements Subproject—Results of Cost-Benefit Analysis

Year	Sharkhad					Tolgoit					Urban Road Improvements
	Costs			Benefits	Net Benefits	Costs			Benefits	Net Benefits	Net Benefits
	Investment	O&M	Total			Investment	O&M	Total			
2021	3,345.6	0.0	3,345.6	0.0	-3,345.6	3,837.0	0.0	3,837.0	0.0	-3,837.0	-7,182.6
2022	2,509.2	0.0	2,509.2	0.0	-2,509.2	2,878.0	0.0	2,878.0	0.0	-2,878.0	-5,387.2
2023	2,509.2	130.0	2,639.2	181.0	-2,458.2	2,877.6	149.0	3,026.6	137.0	-2,889.6	-5,347.8
2024	0.0	260.5	260.5	470.8	210.3	0.0	298.7	298.7	529.3	230.6	440.9
2025	0.0	260.5	260.5	676.8	416.3	0.0	298.7	298.7	777.3	478.5	894.8
2026	0.0	260.5	260.5	894.3	633.8	0.0	298.7	298.7	1,038.6	739.9	1,373.7
2027	0.0	260.5	260.5	1,124.4	863.9	0.0	298.7	298.7	1,314.2	1,015.5	1,879.5
2028	0.0	260.5	260.5	1,367.7	1,107.3	0.0	298.7	298.7	1,605.2	1,306.4	2,413.7
2029	0.0	260.5	260.5	1,625.2	1,364.7	0.0	298.7	298.7	1,911.9	1,613.2	2,977.9
2030	0.0	260.5	260.5	1,897.7	1,637.2	0.0	298.7	298.7	2,236.0	1,937.2	3,574.5
2031	0.0	260.5	260.5	2,185.0	1,924.5	0.0	298.7	298.7	2,577.0	2,278.3	4,202.8
2032	0.0	260.5	260.5	2,487.7	2,227.2	0.0	298.7	298.7	2,935.9	2,637.2	4,864.3
2033	0.0	260.5	260.5	2,806.4	2,546.0	0.0	298.7	298.7	3,313.5	3,014.7	5,560.7
2034	0.0	260.5	260.5	3,141.7	2,881.3	0.0	298.7	298.7	3,710.4	3,411.7	6,293.0
2035	0.0	260.5	260.5	3,494.2	3,233.8	0.0	298.7	298.7	4,127.4	3,828.7	7,062.4
2036	0.0	260.5	260.5	3,864.6	3,604.1	0.0	298.7	298.7	4,565.6	4,266.9	7,870.9
2037	0.0	260.5	260.5	4,253.2	3,992.7	0.0	298.7	298.7	5,025.4	4,726.7	8,719.4
2038	0.0	260.5	260.5	4,660.7	4,400.2	0.0	298.7	298.7	5,507.9	5,209.2	9,609.4
2039	0.0	260.5	260.5	5,087.8	4,827.3	0.0	298.7	298.7	6,013.6	5,714.9	10,542.2
2040	0.0	260.5	260.5	5,534.7	5,274.2	0.0	298.7	298.7	6,543.6	6,244.9	11,519.1
EIRR					14.1%	14.3%					14.2%
ENPV @ 12%					1,548.8	2,001.5					3,550.3

EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operation and maintenance.

Source: Asian Development Bank estimates.

Table 3: Water Supply Improvements Subproject—Results of Cost-Benefit Analysis

Year	Sharkhad							Tolgoit							Water Supply Improvements Net Benefits	
	Costs			Benefits			Net Benefits	Costs			Benefits			Net Benefits		
	Investment	O&M	Total	Non-incremental water	Incremental water	Total		Investment	O&M	Total	Non-incremental water	Incremental water	Total			
2021	1,327.2	0.0	1,327.2	0.0	0.0	0.0	-1,327.2	819.7	0.0	819.7	0.0	0.0	0.0	-819.7	-2,146.9	
2022	1,327.2	0.0	1,327.2	0.0	0.0	0.0	-1,327.2	819.7	0.0	819.7	0.0	0.0	0.0	-819.7	-2,146.9	
2023	663.6	0.0	663.6	0.0	0.0	0.0	-663.6	409.9	0.0	409.9	0.0	0.0	0.0	-409.9	-1,073.5	
2024	0.0	156.6	156.6	8.4	63.2	71.6	-85.0	0.0	96.7	96.7	6.6	47.2	53.8	-42.9	-127.9	
2025	0.0	156.6	156.6	18.1	133.3	151.4	-5.2	0.0	96.7	96.7	14.1	99.5	113.7	17.0	11.8	
2026	0.0	156.6	156.6	36.3	262.6	298.9	142.3	0.0	96.7	96.7	28.4	196.0	224.4	127.7	270.0	
2027	0.0	156.6	156.6	57.3	405.9	463.2	306.6	0.0	96.7	96.7	44.8	303.0	347.8	251.1	557.7	
2028	0.0	156.6	156.6	81.4	564.5	645.9	489.3	0.0	96.7	96.7	63.7	421.3	485.1	388.4	877.7	
2029	0.0	156.6	156.6	109.0	739.6	848.6	692.1	0.0	96.7	96.7	85.3	552.1	637.4	540.7	1,232.8	
2030	0.0	156.6	156.6	140.6	932.9	1,073.5	917.0	0.0	96.7	96.7	110.0	696.3	806.4	709.7	1,626.6	
2031	0.0	193.9	193.9	151.2	992.0	1,143.1	949.2	0.0	119.7	119.7	118.3	751.3	869.6	749.8	1,699.1	
2032	0.0	193.9	193.9	161.7	1,069.1	1,230.9	1,037.0	0.0	119.7	119.7	126.5	809.8	936.3	816.6	1,853.6	
2033	0.0	193.9	193.9	172.3	1,151.1	1,323.4	1,129.5	0.0	119.7	119.7	134.8	872.0	1,006.7	887.0	2,016.5	
2034	0.0	193.9	193.9	182.6	1,238.2	1,420.8	1,227.0	0.0	119.7	119.7	142.9	938.0	1,080.9	961.1	2,188.1	
2035	0.0	193.9	193.9	192.6	1,330.7	1,523.3	1,329.4	0.0	119.7	119.7	150.7	1,008.1	1,158.9	1,039.1	2,368.6	
2036	0.0	229.6	229.6	202.3	1,428.8	1,631.0	1,401.4	0.0	141.8	141.8	158.3	1,098.6	1,256.9	1,115.0	2,516.4	
2037	0.0	229.6	229.6	211.4	1,504.3	1,715.6	1,486.0	0.0	141.8	141.8	165.4	1,108.4	1,273.7	1,131.9	2,617.9	
2038	0.0	229.6	229.6	219.8	1,501.2	1,721.0	1,491.4	0.0	141.8	141.8	172.0	1,106.1	1,278.1	1,136.2	2,627.6	
2039	0.0	229.6	229.6	227.5	1,498.4	1,725.9	1,496.3	0.0	141.8	141.8	178.0	1,104.0	1,282.0	1,140.2	2,636.5	
2040	0.0	229.6	229.6	234.3	1,495.9	1,730.3	1,500.6	0.0	141.8	141.8	183.4	1,102.2	1,285.5	1,143.7	2,644.3	
EIRR							13.5%								16.1%	14.5%
ENPV @ 12%							441.1								824.2	1,265.3

EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operation and maintenance.

Source: Asian Development Bank estimates.

Table 4: Sewerage Improvements Subproject—Results of Cost-Benefit Analysis

Year	Sharkhad							Tolgoit							Sewerage Improvements Net Benefits	
	Costs			Benefits			Net Benefits	Costs			Benefits			Net Benefits		
	Investment	O&M	Total	Avoided DALYs	Avoided medical costs	Total		Investment	O&M	Total	Avoided DALYs	Avoided medical costs	Total			
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2021	806.3	0.0	806.3	0.0	0.0	0.0	-806.3	537.5	0.0	537.5	0.0	0.0	0.0	-537.5	-1,343.8	
2022	806.3	0.0	806.3	0.0	0.0	0.0	-806.3	537.5	0.0	537.5	0.0	0.0	0.0	-537.5	-1,343.8	
2023	403.1	48.4	451.5	6.5	0.2	6.7	-444.8	268.8	32.2	301.0	6.4	0.1	6.5	-294.5	-739.2	
2024	0.0	96.7	96.7	40.0	0.6	40.5	-56.2	0.0	64.5	64.5	19.8	0.2	20.0	-44.5	-100.6	
2025	0.0	96.7	96.7	70.5	0.9	71.3	-25.4	0.0	64.5	64.5	34.9	0.3	35.2	-29.3	-54.6	
2026	0.0	96.7	96.7	123.0	1.4	124.4	27.7	0.0	64.5	64.5	60.9	0.5	61.4	-3.1	24.6	
2027	0.0	96.7	96.7	177.5	1.9	179.4	82.7	0.0	64.5	64.5	93.4	0.8	94.1	29.6	112.4	
2028	0.0	96.7	96.7	203.0	2.0	205.0	108.3	0.0	64.5	64.5	133.9	1.0	135.0	70.5	178.8	
2029	0.0	96.7	96.7	232.1	2.2	234.3	137.6	0.0	64.5	64.5	184.3	1.3	185.6	121.1	258.7	
2030	0.0	96.7	96.7	498.1	4.5	502.5	405.8	0.0	64.5	64.5	246.5	1.7	248.1	183.7	589.5	
2031	0.0	119.7	119.7	567.4	4.8	572.2	452.4	0.0	79.8	79.8	280.8	1.8	282.6	202.7	655.2	
2032	0.0	119.7	119.7	643.3	5.2	648.5	528.7	0.0	79.8	79.8	318.4	1.9	320.3	240.5	769.2	
2033	0.0	119.7	119.7	726.0	5.5	731.5	611.8	0.0	79.8	79.8	359.3	2.0	361.3	281.5	893.3	
2034	0.0	119.7	119.7	815.6	5.8	821.4	701.6	0.0	79.8	79.8	403.6	2.2	405.8	325.9	1,027.6	
2035	0.0	119.7	119.7	911.8	6.1	917.9	798.2	0.0	79.8	79.8	451.2	2.3	453.5	373.7	1,171.8	
2036	0.0	141.8	141.8	1,014.5	6.4	1,021.0	879.1	0.0	94.6	94.6	502.1	2.4	504.5	409.9	1,289.0	
2037	0.0	141.8	141.8	1,123.5	6.7	1,130.2	988.4	0.0	94.6	94.6	556.0	2.5	558.5	463.9	1,452.3	
2038	0.0	141.8	141.8	1,238.2	7.0	1,245.2	1,103.3	0.0	94.6	94.6	612.7	2.6	615.3	520.8	1,624.1	
2039	0.0	141.8	141.8	1,358.0	7.2	1,365.2	1,223.4	0.0	94.6	94.6	672.0	2.7	674.7	580.2	1,803.6	
2040	0.0	141.8	141.8	1,482.2	7.5	1,489.7	1,347.9	0.0	94.6	94.6	733.5	2.8	736.3	641.7	1,989.6	
EIRR							11.8%								8.7%	10.7%
ENPV @ 12%							-45.81								-364.23	-410.05

EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operation and maintenance.

Source: Asian Development Bank estimates.

Table 5: Heating Improvements Subproject—Results of Cost-Benefit Analysis

Year	Sharkhad							Tolgoit							Heating Improvements Net Benefits	
	Costs			Benefits			Net Benefits	Costs			Benefits			Net Benefits		
	Investment	O&M	Total	Avoided DALYs	Avoided medical costs	Total		Investment	O&M	Total	Avoided DALYs	Avoided medical costs	Total			
2021	1,581.9	0.0	1,581.9	0.0	0.0	0.0	-1,581.9	2,707.4	0.0	2,707.4	0.0	0.0	0.0	-2,707.4	-4,289.3	
2022	1,581.9	0.0	1,581.9	0.0	0.0	0.0	-1,581.9	2,707.4	0.0	2,707.4	0.0	0.0	0.0	-2,707.4	-4,289.3	
2023	790.9	95.9	886.9	78.4	1.2	79.6	-807.3	1,353.7	164.2	1,517.9	51.2	0.6	51.8	-1,466.1	-2,273.4	
2024	0.0	191.8	191.8	261.5	3.6	265.1	73.3	0.0	328.3	328.3	156.9	1.6	158.6	-169.8	-96.5	
2025	0.0	191.8	191.8	358.6	4.3	362.9	171.1	0.0	328.3	328.3	276.6	2.5	279.2	-49.2	121.9	
2026	0.0	191.8	191.8	625.7	7.1	632.8	441.0	0.0	328.3	328.3	482.8	4.1	486.9	158.5	599.5	
2027	0.0	191.8	191.8	959.7	10.3	970.0	778.2	0.0	328.3	328.3	740.4	6.0	746.4	418.1	1,196.2	
2028	0.0	191.8	191.8	1,377.0	13.9	1,390.9	1,199.0	0.0	328.3	328.3	1,062.3	8.1	1,070.4	742.1	1,941.1	
2029	0.0	191.8	191.8	1,894.3	18.0	1,912.3	1,720.5	0.0	328.3	328.3	1,461.4	10.5	1,471.9	1,143.6	2,864.0	
2030	0.0	191.8	191.8	2,533.9	22.8	2,556.7	2,364.9	0.0	328.3	328.3	1,955.0	13.2	1,968.2	1,639.8	4,004.7	
2031	0.0	191.8	191.8	2,886.6	24.5	2,911.1	2,719.3	0.0	328.3	328.3	2,227.0	14.2	2,241.2	1,912.9	4,632.2	
2032	0.0	383.7	383.7	3,273.1	26.2	3,299.3	2,915.6	0.0	656.7	656.7	2,525.2	15.2	2,540.4	1,883.7	4,799.3	
2033	0.0	383.7	383.7	3,693.9	27.9	3,721.8	3,338.1	0.0	656.7	656.7	2,849.9	16.2	2,866.1	2,209.4	5,547.5	
2034	0.0	383.7	383.7	4,149.3	29.6	4,178.9	3,795.2	0.0	656.7	656.7	3,201.2	17.2	3,218.4	2,561.7	6,356.9	
2035	0.0	383.7	383.7	4,638.9	31.2	4,670.1	4,286.4	0.0	656.7	656.7	3,578.9	18.1	3,597.0	2,940.3	7,226.7	
2036	0.0	383.7	383.7	5,161.6	32.8	5,194.4	4,810.7	0.0	656.7	656.7	3,982.2	19.0	4,001.2	3,344.5	8,155.2	
2037	0.0	767.4	767.4	5,715.9	34.2	5,750.1	4,982.8	0.0	1,313.3	1,313.3	4,409.8	19.9	4,429.7	3,116.4	8,099.1	
2038	0.0	767.4	767.4	6,299.4	35.6	6,335.0	5,567.6	0.0	1,313.3	1,313.3	4,860.0	20.7	4,880.7	3,567.3	9,135.0	
2039	0.0	767.4	767.4	6,909.1	36.9	6,946.0	6,178.6	0.0	1,313.3	1,313.3	5,330.4	21.4	5,351.8	4,038.5	10,217.1	
2040	0.0	767.4	767.4	7,541.2	38.0	7,579.2	6,811.8	0.0	1,313.3	1,313.3	5,818.1	22.0	5,840.1	4,526.8	11,338.6	
EIRR							24.1%								13.2%	18.1%
ENPV @ 12%							6,849.9								757.1	7,607.0

EIRR = economic internal rate of return, ENPV = economic net present value, O&M = operation and maintenance.

Source: Asian Development Bank estimates.