

### ECONOMIC ANALYSIS FOR TRANCHE 3

1. The economic analysis of subprojects under Tranche 3 of the Ulaanbaatar Urban Services and Ger Areas Development Investment Program was conducted in accordance with ADB's *Guidelines for the Economic Analysis of Projects*, *Framework for the Economic and Financial Appraisal of Urban Development Sector Projects*, and *Handbook for Integrating Risk Analysis in the Economic Analysis of Projects*.<sup>1</sup> The methodology follows that used for Tranches 1 and 2.<sup>2</sup>
2. Capital costs were estimated based on the concept designs prepared during the feasibility studies. These, inclusive of physical contingencies and operations and maintenance (O&M) costs, were converted into economic terms by subtracting all transfer payments, including taxes and duties, and applying the domestic price numeraire (adjusting border prices to equivalent domestic values) with the shadow exchange rate factor of 1.01 for tradable goods. Given considerable underemployment in Ulaanbaatar for unskilled labor, shadow wage rate factors of 0.8 and 1.0 were applied to unskilled and skilled labor, respectively.<sup>3</sup> These same conversion factors were used to estimate benefits in economic terms.
3. The analysis assumes a 3-year construction period starting in 2021, with most projects to be completed in the second half of 2023, and evaluates annual costs and benefits until 2040. It uses constant 2019 prices and a conversion rate of MNT2,668:\$1.
4. The population in the project areas (Sharkhad and Tolgoit) is currently growing at annual averages of 1.7%–2.1%. It is expected that upon implementation of the project, population growth in the project areas would increase to 6.0%–7.0% every year; and the number of residents will increase from 9,046 (2019) to 33,027 by 2040 in Sharkhad, and 6,979 (2019) to 25,480 by 2040 in Tolgoit. Detailed projections are presented in Supplementary Appendix 18. There are an estimated 4.28 persons per household in Sharkhad, and 4.25 persons per household in Tolgoit.

#### A. Urban Roads Improvement

5. The proposed subproject will construct a 16.62-kilometer (km) paved road (width of 14.7 meters [m] and 24.7 m) costing \$8.4 million in Sharkhad and \$9.6 million in Tolgoit. O&M cost is estimated to be \$260,476 in Sharkhad and \$298,720 in Tolgoit each year between 2024 and 2040 and half of the annual O&M costs incurred in 2023.
6. The analysis assumes the following benefits from better roads and other related urban improvements, such as street lighting and green space:
  - (i) **Higher potential annualized rental benefits from the use of the land surrounding the improved roads.** Average monthly rent is estimated at \$1.7 per square meter (m<sup>2</sup>),<sup>4</sup> assumed to increase by 5% each year under the project in accordance with planned development in the project areas. It will be applied to the leasable space shown in Table 1.

<sup>1</sup> ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila; ADB. 1994. *Framework for the Economic and Financial Appraisal of Urban Development Sector Projects*. Manila; and ADB. 2002. *Handbook for Integrating Risk Analysis in the Economic Analysis of Projects*. Manila.

<sup>2</sup> ADB. 2013. *Feasibility Study Report on the Ulaanbaatar Urban Services and Ger Areas Development Investment Program*. Consultant's report. Manila (TA 7970-MON).

<sup>3</sup> These conversion factors are consistent with similar projects of the same nature in Mongolia. For example, ADB. 2018. *Report and Recommendation of the President to the Board of Directors: Ulaanbaatar Green Affordable Housing and Resilient Urban Renewal Sector Project*. Manila.

<sup>4</sup> According to the [Numbeo](#) database (accessed November 2019), the monthly rent for a 40 m<sup>2</sup> apartment outside the city center is MNT452,000 (\$169.4), or \$4.2/m<sup>2</sup>. Following the economic analyses for Tranches 1 and 2, the monthly rate in the project areas is assumed to be 40% of this figure.

**Table 1: Leasable Space in Sharkhad and Tolgoit**  
(square meter)

Project Area		Area of Influence	Leasable Space (2023)	Leasable Space (2024, Onwards)
<b>Sharkhad</b>	1.2 million	620,000	155,000	170,500
<b>Tolgoit</b>	1.5 million	767,000	191,750	210,925

Note: Following the methodology for Tranches 1 and 2, the area of influence is estimated as 50% of the total project area; and leasable space as 25% of the area of influence in Year 1, with a one-time 10% increase in Year 2.

Source: Asian Development Bank estimates.

- (ii) **Vehicle operating cost savings from improved road conditions.** Forty percent of households in the project areas are assumed to own a vehicle. Operating cost savings are estimated to start at \$93<sup>5</sup> per household in 2023, increasing by 5% a year.

7. The cost-benefit analysis finds both road subprojects to be economically viable. Economic internal rates of return (EIRR) are 14.1% and 14.3% in Sharkhad and Tolgoit, respectively, higher than the threshold rate of 12.0%.<sup>6</sup> The sensitivity analysis shows that viability is generally robust in scenarios where costs are increased, and sensitive to scenarios affecting benefits. Table 2 shows the results of the cost-benefit and sensitivity analyses for all subprojects, while detailed estimates are presented in Supplementary Appendix 18.

## B. Water Supply Improvement

8. The proposed subproject will construct 11.0 km of piped water distribution network and pumping station with capacity of 6,000 cubic meters per day (m<sup>3</sup>/d) in Sharkhad, and 6.3 km of piped water distribution network and pumping station with capacity of 4,600 m<sup>3</sup>/d in Tolgoit. The investment cost is estimated at \$3.3 million in Sharkhad and \$2.0 million in Tolgoit. On average, annual O&M will cost \$189,032 in Sharkhad and \$116,755 in Tolgoit between 2024 and 2040. These costs increase over time as subproject assets become more widely used. Annual technical and non-technical losses are assumed to total 18% of capacity, reducing the supply delivered.

9. Service coverage in both project areas is projected to increase from 7.5% of total households in 2024 to 15.0% in 2025, and finally to 80% in 2030 (held constant until 2040). This means that connected households will rise from 221 in 2024 to 6,173 by 2040 in Sharkhad, and from 172 in 2024 to 4,796 by 2040 in Tolgoit. Connected businesses are projected to increase from 10 in 2024 to 301 by 2040 in Sharkhad, and from 8 in 2024 to 261 by 2040 in Tolgoit.

10. The water supply improvement will provide the following benefits:

- (i) **Resource savings on non-incremental water supplied to connected households.** Without the project, residential consumption is estimated to remain at 10 liters per capita per day (l/c/d) (0.01 m<sup>3</sup>). Surveys conducted for the feasibility study indicated that each household averages 3.5 trips a week, each taking 30 minutes, to access water from kiosks, delivery trucks, and other sources. This time was valued at \$0.5 per hour in both project areas, based on an estimated average monthly income per person of \$110.5 in Sharkhad and \$111.2 in Tolgoit.<sup>7</sup>

<sup>5</sup> The economic analysis for Tranche 1 estimated the vehicle operating cost at \$175 for each vehicle, based on results of the survey conducted as part of the feasibility study, and assumed one vehicle per household. The cost figure was retained for Tranche 2, but this analysis updates it to \$93 due to exchange rate movements.

<sup>6</sup> This analysis still uses the 12% social discount rate for consistency with Tranches 1 and 2.

<sup>7</sup> Based on average monthly household income as shown in National Statistics Office of Mongolia. 2020. [Social and economic situation of Mongolia \(January 2020\)](#). This was converted to US dollars using the project exchange rate,

- (ii) **Incremental water sales to connected households and businesses.** With the project, household consumption is increased to 50 l/c/d. The amount exceeding existing consumption (estimated in para. 10[i]) was valued at willingness to pay (WTP) equal to \$5.73 per month in Sharkhad and \$5.47 per month in Tolgoit, based on the surveys conducted in the project areas. In addition, each connected business is expected to consume 16 m<sup>3</sup>/d up to the maximum with-project supply available. In the absence of data on current consumption and WTP for businesses, business consumption is treated as 100% incremental and also valued at household WTP.

11. The water supply improvement subprojects are found to be economically viable, with EIRRs of 13.5% in Sharkhad and 16.1% in Tolgoit. Viability remains robust across all adverse scenarios, but the Sharkhad subproject becomes unviable when benefits are delayed, or when both costs and benefits are manipulated.

### C. Sewerage Improvement

12. There is no sewerage system in the proposed project areas. Consequently, households often pour their wastewater into the streets. This is the main reason for the incidence of infectious diseases in the project areas and Ulaanbaatar city. The proposed subproject will install sewerage pipelines in Sharkhad and Tolgoit, costing \$2.0 million and \$1.3 million, respectively. O&M cost will average \$112,655 in Sharkhad subproject and \$75,303 in Tolgoit each year between the second half of 2023 up to 2040. O&M costs will rise over time due to increased use of the sewerage systems.

13. Beneficiary coverage in both project areas is projected to increase from 3.8% of the population in late 2023 to 15.0% in 2025, and finally to 80% in 2030. An additional 10% of the population is estimated to benefit every year from spillover effects of having generally cleaner surroundings.

14. The sewerage improvement is expected to bring about the following benefits:

- (i) **Reduced exposure to water-related health risks**, quantified as the number of avoided disability-adjusted life-years (DALYs), i.e., years lost to ill-health, disability, or early death. Waterborne diseases<sup>8</sup> are assumed to result in 535 DALYs per 100,000 persons in Mongolia,<sup>9</sup> held constant over the evaluation period and applied to the populations of Sharkhad and Tolgoit to compute the applicable number of DALYs in the project areas. Following the World Health Organization approach, the annual economic value of a DALY is forecast to increase from \$3,660.0 in 2018<sup>10</sup> to \$4,814.2 in 2024, and \$13,283.7 by 2040. Of this, 45% is assumed to be avoided under the subproject given that there are no existing sewerage systems in the project areas.
- (ii) **Savings in medical expenses of households previously exposed to soil pollution through untreated groundwater.** Surveys conducted during the feasibility study shows that total medical expenses amount to \$91 per household in Sharkhad and \$68 per household in Tolgoit. Of these totals, 1.6% is assumed to be for waterborne diseases (the proportion of DALYs from waterborne diseases to total

---

divided by the average number of persons per household, and 10% personal income tax deducted before being converted to economic terms using the project shadow wage rate factor for unskilled labor. Personal income tax rate taken from PwC Worldwide Tax Summaries Online. [Mongolia - Taxes on personal income](#).

<sup>8</sup> Defined in this analysis as comprising diarrheal disease, hepatitis A and E, parasitic and vector diseases (50% of DALYs), encephalitis (50%), intestinal nematode infections (50%), other infectious diseases (50%), and skin diseases (50%).

<sup>9</sup> Derived from World Health Organization. [Global Health Estimates](#) (accessed 6 March 2020).

<sup>10</sup> Gross national income per capita in current US dollars (Atlas method) from World Bank. [World Development Indicators](#) (accessed 6 March 2020).

DALYs in Mongolia). The subproject is assumed to help households—both those directly connected to the network and those enjoying spillover benefits—save 45% of medical expenses for waterborne diseases.

15. The cost-benefit analysis finds that the sewerage improvement subprojects are economically unviable against the 12.0% threshold, with EIRRs of 11.8% in Sharkhad and 8.7% in Tolgoit. However, benefits are believed to be understated because the economic analysis for this subproject does not capture WTP for a reliable sewerage service.

#### D. Heating Improvement

16. Residents in Sharkhad and Tolgoit burn coal for heating during the winter since there are no heating connections in the project areas. The resulting smoke emissions are the main cause of air pollution and respiratory disease among residents. The proposed subproject will install in Sharkhad three thermal substations with a 2.6 km thermal power line, costing \$4.0 million; and in Tolgoit, four thermal substations with a 5.5 km thermal power line costing \$6.8 million. Annual O&M will average \$367,694 in Sharkhad and \$629,306 in Tolgoit between late 2023 and 2040, with these costs rising over time due to increased use of heating subprojects.

17. Assumptions on beneficiary coverage and spillover benefits are the same as those described in para. 15. The heating subproject is expected to bring about the following benefits:

- (i) **Reduced exposure to airborne health risks**, quantified as the number of avoided DALYs. Airborne diseases<sup>11</sup> are assumed to result in 5,457 DALYs per 100,000 persons in Mongolia (footnote 9), held constant over the evaluation period and applied to the populations of Sharkhad and Tolgoit to compute the applicable number of DALYs in the project areas. The annual economic value of these DALYs is the same as in para. 15(i). Of this, 35% is avoided under the subproject.
- (ii) **Savings in medical expenses of households from improved air quality**. Of the total medical expenses per household described in para. 15(ii), 17.2% is assumed to be for airborne diseases (the proportion of DALYs from airborne diseases to total DALYs in Mongolia). The subproject is assumed to help households—again, both those directly connected to the network and those enjoying spillover benefits—save 35% of medical expenses for airborne diseases.

18. The cost-benefit analysis finds both heating subprojects to be economically viable, with EIRRs of 24.1% in Sharkhad and 13.2% in Tolgoit. Benefits may again be understated because this analysis does not capture households' WTP for the service. The sensitivity analysis shows that viability is generally robust in scenarios where costs are increased, and sensitive to scenarios affecting benefits. The Tolgoit subproject becomes unviable when benefits are reduced or delayed.

#### E. Overall Economic Analysis Results

19. All Tranche 3 subprojects are found to be economically viable, except for the sewerage subproject whose benefits may be understated. The EIRR for all subprojects taken together is 15.3%, and the overall project stays viable across all scenarios of the sensitivity analysis. Total investments in Sharkhad and Tolgoit are viable as well, with EIRRs of 16.8% and 13.8%, respectively, for all subprojects in each project area. The combined investment in Tolgoit becomes unviable when benefits are delayed, or when both costs and benefits are manipulated.

---

<sup>11</sup> Defined in this analysis as comprising communicable and non-communicable respiratory ailments.

**Table 2: Results of Cost-Benefit and Sensitivity Analyses**

Subproject and Scenario	Sharkhad			Tolgoit			Combined		
	EIRR (%)	ENPV (\$'000)	Switching Value (%)	EIRR (%)	ENPV (\$'000)	Switching Value (%)	EIRR (%)	ENPV (\$'000)	Switching Value (%)
<b>Urban Roads Improvement</b>									
Base case	14.1	1,548.8		14.3	2,001.5		14.2	3,550.3	
Capital cost +10%	13.1	872.0	21.3	13.4	1,225.0	23.7	13.2	2,096.2	24.4
O&M cost +10%	14.1	1,526.0	662.0	14.3	1,976.0	742.0	14.0	3,247.1	117.1
Benefits -10%	12.8	575.0	16.3	13.1	863.0	18.2	12.9	1,437.9	(16.8)
Total costs +10%; Benefits -10%	11.7	(243.0)		11.9	(76.0)		11.8	(319.5)	
Benefits delayed by 1 year	12.0	(6.0)		12.2	176.0		12.1	150.9	
<b>Water Supply Improvement</b>									
Base case	13.5	441.1		16.1	824.2		14.5	1,265.3	
Capital cost +10%	12.5	169.5	15.7	15.1	656.5	40.7	13.6	826.0	28.8
O&M cost +10%	13.2	352.6	50.5	15.8	769.5	156.4	14.3	1,122.1	88.4
Benefits -10%	12.1	36.9	(11.0)	14.7	519.4	(29.5)	13.2	556.3	(17.8)
Total costs +10%; Benefits -10%	10.9	(323.1)		13.5	297.0		11.9	(26.0)	
Benefits delayed by 1 year	11.5	(152.1)		13.9	378.7		12.5	226.6	
<b>Sewerage Improvement</b>									
Base case	11.8	(45.8)		8.7	(364.2)		10.7	(410.0)	
Capital cost +10%	11.0	(210.8)	(3.0)	8.0	(474.2)	(43.3)	9.9	(685.0)	(14.9)
O&M cost +10%	11.5	(103.9)	(7.9)	8.4	(403.0)	(91.1)	10.3	(506.9)	(42.4)
Benefits -10%	10.6	(264.3)	2.0	7.5	(476.5)	26.9	9.5	(740.8)	12.4
Total costs +10%; Benefits -10%	9.5	(487.3)		6.4	(625.2)		8.4	(1,112.5)	0.0
Benefits delayed by 1 year	9.8	(417.8)		6.9	(552.7)		8.7	(970.5)	
<b>Heating Improvement</b>									
Base case	24.1	6,849.9		13.2	757.1		18.1	7,607.0	
Capital cost +10%	23.0	6,526.2	106.4	12.3	203.2	13.4	17.1	6,729.4	86.7
O&M cost +10%	24.1	6,834.6	4,963.9	12.8	525.5	33.5	17.8	7,193.7	184.0
Benefits -10%	22.6	5,688.8	(80.1)	11.8	(133.4)	(8.4)	16.7	5,555.4	(37.1)
Total costs +10%; Benefits -10%	21.3	5,212.7		10.5	(948.2)		15.5	4,264.5	
Benefits delayed by 1 year	20.9	4,904.3		10.8	(737.6)		15.5	4,166.8	
<b>Overall Tranche 3</b>									
Base case	16.8	8,793.9		13.8	3,218.7		15.3	12,012.6	
Capital cost +10%	15.8	7,356.4	61.2	12.8	1,610.2	20.0	14.3	8,966.6	39.4
O&M cost +10%	16.6	8,353.6	199.7	13.5	2,702.4	62.3	15.0	11,056.0	125.6
Benefits -10%	15.5	6,036.8	(31.9)	12.4	772.1	(13.2)	14.0	6,808.9	(23.1)
Total costs +10%; Benefits -10%	14.3	4,159.0		11.3	(1,352.6)		12.8	2,806.4	0.0
Benefits delayed by 1 year	14.4	4,328.0		11.6	(736.0)		13.0	3,591.9	

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

Source: Asian Development Bank estimates.