ECONOMIC ANALYSIS

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]

2. **Sector context.** Yangon City experiences frequent severe storms, floods, saltwater intrusion, and extreme temperatures. The Ngamoeyeik reservoir system is the source of about 66% of the water delivered to the Yangon City residents who are serviced by the Yangon City Development Committee (YCDC). This water is transferred from the reservoir to the water treatment plant at Nyaungnhapin via an open canal, the main section of which is under the control of the Ministry of Agriculture, Livestock and Irrigation. The system is not resilient as the open canal is vulnerable to evaporation, seepage, and pollution; and the YCDC does not have full control of the canal.

3. **Economic rationale**. The YCDC is responsible for supplying water to 33 of the 45 townships of Yangon Region. The YCDC systems deliver about 932 million liters per day (MLD) to customers, of which 841 MLD comes from surface water sources and 91 MLD is from groundwater resources. The Ngamoeyeik reservoir provides 614 MLD per day to the YCDC water system, of which only 409 MLD is treated at the water treatment plant.

4. With a population of about 5.2 million and an area of 895 square kilometers (km^2), Yangon is the largest city and main economic hub of the country and the capital of Yangon Region. The city's population represents 10% of the national population and 35% of the urban population, while it contributes about 23% of the country's gross domestic product. Yangon City's population grew at 2.20% annually between 2014 and 2019, more than three times faster than the country's total annual population growth of 0.67% in the same period. In 2017, Yangon had 30 industrial zones, which have been the most popular destination for internal migration.

5. Rural–urban migration is a new phenomenon in Myanmar that is expected to result in major demographic shifts during the period from 2020 to 2029. The changing composition of the labor force because of rising demand from the manufacturing sector is also a driver of urbanization. During the period from 2010 to 2014, internal migration accounted for 81% of the demographic growth in Yangon City. Despite this large influx of migrants, unemployment has remained low, demonstrating that the city's rapid industrial development has been able to absorb this large flow of migrants.

6. **Demand analysis**. The water supply service rate in the project area was estimated at only 35% in 2014, meaning that 65% of the population obtained their water from private wells or suppliers. Table 1 shows the estimated future annual demand in the service area of the project. The projections reveal that, using fairly conservative assumptions, demand in the existing service area will increase to 846 MLD by 2025.

Table 1: Water Demand Projections, 2014–2040 (million liters per day)

Item	2014	2020	2025	2030	2040
Total service area demand	514	741	846	850	982

Source: Asian Development Bank estimates.

[1] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.

7. **Least-cost analysis.** Least-cost analysis was completed for alternative engineering options for the raw water transmission system. The comparison was between a reinforced concrete pipe as the base option and a steel pipe as the alternative. The analysis also involved the option of including a pumping station of 818 MLD capacity to allow for a reduction of the pipe diameter from 2.9 meters to 2.4 meters, thus significantly reducing the cost of the pipeline and its installation. Given the limited difference in the recurrent costs of the two pipeline options, the reinforced concrete pipe with pumping station was identified as the least-cost option.

8. **Cost–benefit analysis.** Cost–benefit analysis was conducted for the overall project, which includes both project outputs—main raw water transmission system constructed and institutional sustainability strengthened. The projected economic benefit and cost flows were estimated using with- and without-project scenarios and projected over 30 years.[2] The incremental economic benefit and cost flows provided the basis for calculating the economic net present value and the economic internal rate of return (EIRR).

9. The major assumptions used for the economic analysis are as follows: (i) the project life is 30 years with a construction period of 5 years and annual maintenance for the 25-year production period; (ii) all prices and costs are expressed in mid-2019 prices and converted at an exchange rate of $1.00 = MK1,505; (iii) economic benefits and costs are valued in the domestic price numeraire; (iv) physical contingencies of 10% are included in the investment cost; (v) taxes, duties, and price contingencies are excluded from the financial cost; (vi) the economic opportunity cost of capital is 9% per year; (vii) a shadow exchange rate factor of 1.03 is used to convert the financial prices of traded goods to economic prices; (viii) nontraded goods are valued at domestic market prices; (ix) a shadow wage rate factor of 0.90 is used to convert the financial wage rate of unskilled labor to an economic opportunity cost of labor.[3]

10. **Economic benefits.** The estimated economic benefits comprise three types of quantifiable benefits: (i) water saved by transmitting 614 MLD through a pipeline rather than the existing canal, (ii) avoided operation and maintenance (O&M) costs, and (iii) savings from the projected future cost of canal failure. The net present value of the total project economic benefits for 30 years is MK206.3 billion: MK99.3 billion for water saved, MK10.6 billion for avoided O&M costs, and MK96.4 billion for the projected cost of canal failure.

11. **Economic benefits of water saving.** The economic benefits of water saving are based on the assessment that the current delivery of 614 MLD of raw water to the water treatment plant and for direct delivery to consumers incurs a 30% loss from the inlet point.[4] Thus, with the amount delivered representing only 70% of the source amount, the initial input is estimated at 877 MLD and transmission losses at 263 MLD, equivalent to a loss of 0.263 million cubic meters (m^3) per day or about 96 million m^3 per year. The economic value of this water is calculated based on its alternative use.

[2] The pipe is expected to last for much longer, although some of the associated equipment will probably need to be replaced. However, the discounted economic value of costs and benefits beyond year 30 will not significantly affect the economic analysis and have therefore been ignored.

[3] The shadow exchange rate and wage rate factors are from the report and recommendation of the President for the Mandalay Urban Services Improvement Project (ADB. 2015. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Administration of Grant Republic of the Union of Myanmar for the Mandalay Urban Services Improvement Project*. Manila).

[4] The assessment is based on Ngamoeyeik reservoir simulation component final report submitted by the project preparation study team of Cities Development Initiative Asia in July 2019.

12. While at this time it is not planned to transmit more than 614 MLD through the pipeline, the total distributable amount with additional pumping could be increased to 818 MLD after an associated, subsequent project. The water is therefore valued as the potential incremental consumption based on the results of the contingent valuation survey. The estimated value of water supply in the survey was MK162 per m^3.[5] This is used to estimate the value of water saved, which is converted to its economic value on the basis that it is a nontraded commodity.

13. **Economic benefit of avoided operation and maintenance costs.** The economic benefit of reduced O&M costs is estimated through two components. First, O&M costs for the existing 10.9 km long YCDC canal and 25.4 km long irrigation canal can be saved after the installation of the new pipeline. The savings of annual O&M costs for the canal owned by the YCDC are estimated at 1% of the value of MK3,763 million per kilometer, or a total of MK0.41 billion. The savings of annual O&M costs for the irrigation canal are estimated at 0.5% of the value of MK4,214 million per km, or a total value of MK0.54 billion. Second, the O&M costs at the Nyaungnhapin water treatment plant are expected to be lower because the quality of water will be improved, reducing the use of chemicals and other consumables. The estimated saving of annual O&M costs is MK0.59 billion.

14. **Economic benefits of savings from projected future cost of canal failure.** While failure has not been a major issue during the first 15 years of the canal's life, it is likely to become more critical as pressure is placed on it to deliver more water to satisfy the ever-increasing demand from the city's population. Based on experience elsewhere, the average frequency of canal failure over the project life is expected to be once a year and the duration of the failure is estimated at 6 days. During this period, about 50% of the households will purchase an average of 50% of their daily consumption of water.

15. The affected population is forecast based on the water supply coverage of 35% in 2020, or about 1.181 million people. This converts to 251,716 households based on a household size of 4.69 persons, as indicated by the household survey.

16. The adjusted household survey results also indicated that average daily water consumption is 1.17 m^3 per household, equivalent to 58 20-liter bottles, the most frequent form of purchase. If this amount of water is purchased, the average cost is MK584 per 20-liter bottle. Combining these values results in an estimated average annual value of water that would need to be purchased during the period from 2025 to 2049 of MK15.8 billion, which as a nontraded product, is assumed to be its economic value.

17. **Economic costs and benefits.** The economic costs include (i) investment costs (e.g., civil works, equipment, materials, and social and environment monitoring costs); and (ii) the cost of O&M. The economic net present value is MK19.2 billion based on a discount rate of 9%, and the EIRR is 10.0% (Table 2). The EIRR exceeds the economic opportunity cost of capital, confirming the project's economic viability. The project's economic viability would increase if the analysis considered economic benefits such as improved health conditions of people in the project area and other unquantifiable benefits from environmental improvements.

[5] The contingent valuation survey conducted by the project preparatory technical assistance team assessed the unit price of water by the willingness-to-pay of the consumers, not the current financial charge to consumers or cost of an input. This means that the unit price of water is the economic value of consumers' willingness to pay for the environmental improvement and improved water quality, not the financial value of raw or treated water from Ngamoeyeik reservoir.

Table 2: Economic Internal Rate of Return for the Raw Water Transmission System Constructed Output

(MK billion)

	Costs			Benefits				
Year	Investment	Recurrent	Total	Water Saved	Avoided Recurrent Costs	Canal Failure	Total	Incremental Net Benefit
2020	4.4	0.0	**4.4**	0.0	0.0	0.0	**0.0**	(4.4)
2021	38.4	0.0	**38.4**	0.0	0.0	0.0	**0.0**	(38.4)
2022	82.6	0.0	**82.6**	0.0	0.0	0.0	**0.0**	(82.6)
2023	82.5	0.0	**82.5**	0.0	0.0	0.0	**0.0**	(82.5)
2024	37.0	0.0	**37.0**	0.0	0.0	0.0	**0.0**	(37.0)
2025	1.7	0.5	**2.3**	15.6	1.5	13.7	**30.8**	28.5
2026	0.0	0.5	**0.5**	15.6	1.5	13.9	**31.0**	30.4
2027		0.5	**0.5**	15.6	1.6	14.0	**31.2**	30.6
2028		0.5	**0.5**	15.6	1.6	14.2	**31.4**	30.8
2029		0.5	**0.5**	15.6	1.6	14.4	**31.6**	31.0
2030		0.5	**0.5**	15.6	1.6	14.6	**31.8**	31.2
2031		0.5	**0.5**	15.6	1.6	14.8	**32.0**	31.4
2032		0.5	**0.5**	15.6	1.6	15.0	**32.1**	31.6
2033		0.5	**0.5**	15.6	1.7	15.1	**32.3**	31.8
2034		0.5	**0.5**	15.6	1.7	15.3	**32.5**	32.0
2035		0.5	**0.5**	15.6	1.7	15.5	**32.7**	32.2
2036		0.5	**0.5**	15.6	1.7	15.7	**32.9**	32.4
2037		0.5	**0.5**	15.6	1.7	15.8	**33.1**	32.6
2038		0.5	**0.5**	15.6	1.7	16.0	**33.3**	32.8
2039		0.5	**0.5**	15.6	1.8	16.2	**33.5**	33.0
2040		0.5	**0.5**	15.6	1.8	16.4	**33.7**	33.2
2041		0.5	**0.5**	15.6	1.8	16.6	**33.9**	33.4
2042		0.5	**0.5**	15.6	1.8	16.7	**34.1**	33.6
2043		0.5	**0.5**	15.6	1.8	16.9	**34.3**	33.8
2044		0.5	**0.5**	15.6	1.9	17.1	**34.5**	34.0
2045		0.5	**0.5**	15.6	1.9	17.3	**34.7**	34.2
2046		0.5	**0.5**	15.6	1.9	17.5	**34.9**	34.4
2047		0.5	**0.5**	15.6	1.9	17.7	**35.1**	34.6
2048		0.5	**0.5**	15.6	1.9	17.9	**35.3**	34.8
2049		0.5	**0.5**	15.6	1.9	18.1	**35.6**	35.0
ENPV	183.7	3.4	**187.1**	99.3	10.6	96.4	**206.3**	19.2
EIRR								10.0%

( ) = negative, EIRR = economic internal rate of return, ENPV = economic net present value.
Source: Asian Development Bank estimates.

18. **Sensitivity analysis.** Sensitivity analysis examined the impact of changes in costs and benefits and delay in achieving the economic benefits. Five sensitivity scenarios were tested: (i) a 10% increase in investment costs, (ii) a 10% increase in O&M costs, (iii) a 10% decrease in benefits, (iv) a 10% increase in investment costs combined with a 10% decrease in benefits, and (v) a 1-year delay in benefits. The estimated EIRR for the raw water transmission system remains above 9% for a 10% cost increase and it drops marginally to 8.9% for a 10% benefit decrease. Combining these scenarios results in an EIRR of 8.0%. Under a 1-year benefit lag, the output decreases but remains viable. The results of the analysis suggest that the output is sensitive to the identified sources of risk (Table 3). However, the level of sensitivity is negligible considering the very conservative estimation of the economic benefits and the exclusion of unquantifiable

environmental and social benefits with positive long-term effects on people's quality of life in Yangon.

Table 3: Economic Viability and Sensitivity Analysis

Sensitivity Test	EIRR (%)	NPV (MK billion)	Sensitivity Indicator	Switching Value (%)[a]
Base case	10.0	19.2		
Increase investment cost by 10%	9.1	0.8	9.3	11.0
Increase in O&M costs by 10%	10.0	18.8	7.7	50.0
Decrease in benefits by 10%	8.9	(1.5)	11.4	9.0
Increase investment cost by 10%				
Decrease in benefits by 10%	8.0	(19.8)		
1-year benefit lag	9.0	(0.3)		

( ) = negative, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance.
[a] Switching value is the percentage increase or decrease in costs or benefits to maintain an EIRR equal to the economic opportunity cost of capital of 9%.
Source: Asian Development Bank estimates.