DETAILED ECONOMIC ANALYSIS

A. Country Context

1. Uzbekistan's economy has grown rapidly in the past decade, lifting significant parts of the population out of poverty. Increased exports of gas, gold, and copper, combined with high commodity prices, have boosted the economy enabling it to expand at an unprecedented rate. As the economy rapidly transforms, however, addressing and balancing regional disparities have become a major development challenge. Some regions are growing at much faster rates than the country's average, while others are lagging behind. The Government of Uzbekistan is responding to this challenge and has developed a regional development program aimed at increasing per capita gross regional product (GRP) in the five regions where poverty incidence is highest.[1] One of the five identified lagging regions in the country, Karakalpakstan is often described as the poorest in Uzbekistan. It suffers from extensive droughts, partly due to weather patterns, but also largely because the waters in the Amu and Syr Darya rivers which feed the region's Aral Sea were once diverted into cotton and rice farmlands by Soviet irrigation projects. The consequent shrinking of the Aral Sea dubbed as "one of the planet's worst environmental disasters" has rendered Karakalpakstan, once a thriving agricultural and fishing area, almost desolate with a devastated local economy.[2]

B. Sector Context

2. Karakalpakstan, which occupies the entire north-western end of Uzbekistan, is primarily an arid desert, composed of sparse, barren lands subject to severe droughts. Water resources suitable for drinking water in the region are limited, made worse due to the aforementioned Aral Sea environmental disaster. In addition, the river flow from the Amu Darya, one of the region's primary source of water supply is projected to decline in the coming years due to receding glaciers in the upstream areas of Tajikistan. Higher demand upstream, reflecting the combined effects of changing rainfall patterns and increased evaporation due to higher temperatures, will further amplify the water stress and competition that already exist among the various areas highly vulnerable to climate change in Central Asia. Groundwater is pervasive throughout Karakalpakstan but is mostly brackish and prohibitively expensive to treat for human consumption.

3. The water supply system of Karakalpakstan consists of three main water treatment plants and interregional transmission and distribution mains owned and operated by Tuyamuyun-Nukus (TN). Just like many of its Soviet-style counterparts in Central Asia, the system is outdated and deteriorated as well as poorly maintained. Consequently, it has become unreliable, with water supply available for only a few hours each day. The system's leakage losses are increasing and the water quality it produces is poor. Only about a third of Karakalpakstan's population is connected to TN's centralized water supply system. Connectivity varies from 65% in the urban

[1] The five regions are Jizzak, Namangan, Surkhandayra, Kzhorezm, and the Republic of Karakalpakstan.

[2] The Aral Sea is an endorheic lake, or closed drainage basin, lying between the Republic of Karakalpakstan in the south and Kazakhstan in the north. Formerly one of the four largest lakes in the world, the Aral Sea has been shrinking. Early in the 20th century, the shrinking was blamed on the rate of evaporation exceeding the rate of inflow but in the 1960s, the shrinking accelerated after the rivers that fed it were diverted by Soviet irrigation projects into vast cotton and rice farmlands located upstream. By 1997, the Aral Sea had been reduced to a mere 10% of its original size. The shrinking of the Aral Sea has been called "one of the planet's worst environmental disasters," bringing unemployment and economic hardships into the Karakalpakstan region.

centers, to 22% in the surrounding outer settlements, declining to as low as 13% in the rural areas. Many households in Karakalpakstan link the limited supply and poor quality of water in the region to the surge of infectious diseases in their districts.

C. Economic Rationale

4. The project will contribute to narrowing the regional imbalance in Uzbekistan by improving the public health, as well as living and economic, conditions in Karakalpakstan. It will address both private market failure and the deficient level of public investment in the region for adequate water supply. These two key factors combined have caused water supply in the RK to be unsafe and unreliable. The situation compounded by the region's increasing vulnerability to climate change will exacerbate the economic, environmental, and health issues confronting Karakalpakstan.

5. The project will expand and upgrade water supply infrastructure in the urban and rural areas of six selected project districts of the RK. Planned infrastructure improvements include the construction and rehabilitation of water transmission mains, water distribution pipes, distribution centers, the rehabilitation of two existing water treatment plants (WTPs), and the construction of a new WTP. Overall, the project will expand access to more climate resilient, reliable and affordable water supply services in the RK for an estimated 400,000 people. It will also improve the operations and business model of TN, the sole water and sewerage service provider in the region, contributing to its financial and institutional sustainability in the long-run.

D. Demand Analysis

6. Residential demand for water was estimated based on a 25-year population forecast prepared by the Design Institute under the Ministry of Housing and Communal Services (MHCS). **Table ST-1** presents details of the population projections.[3] A technical due diligence report prepared under the project preparatory technical assistance (PPTA), and subsequently complemented by a poverty and social assessment (PSA) survey, revealed that only 36.6% of the total population in the Karakalpakstan project areas had access to piped water. To calculate the incremental residential demand for water generated by the project, it was assumed that the remaining unserved population in the district areas would finally be connected to the central water supply system through the project. For this, the water consumption rate of the target households was used, starting from an average of 50 liters per capita per day (lpcd), and gradually increasing to the target 120 lpcd by 2040. For the commercial and institutional users, their incremental consumption was estimated by taking 20% and 10% of residential demand, respectively.[4] The PSA survey further reported that the average current water consumption in the project areas is 37 lpcd. Piped water consumption, however, just averaged 10 lpcd. Nonincremental demand arising from switching to the piped water to be generated by the project from the use of alternative water sources is, thus, high at 27 lpcd. The PSA survey identified the following as the main sources of drinking water in the project areas other than piped water: (i) hand pumps, (ii) bottled

[3] Table ST-1 is a supplementary table that provides the details of the population projections prepared by the Design Institute of the MHCS. Throughout this report, additional supplementary tables will be referenced to provide information more detailed than those provided in the main tables. All referenced supplementary tables cited have been appended at the end of this supplementary report as Annex A.

[4] These estimates were also provided by the Design Institute of the MHCS. This is a commonly used assumption in the planning of water supply networks. See for example, A. Worthington, "Commercial and industrial water demand estimation: Theoretical and methodological guidelines for applied economics research, " Griffith Business School, Australia, 2010.

water purchased from water purifying centers or delivered by trucks, and (iii) open sources such as drainage canals and rivers.

6. Based on the Design Institute's forecasts, incremental water demand in the project areas will reach 4.5 million m^3 per year by 2023, almost doubling to 10.1 million m^3 per year by 2030. By 2040, the incremental water demand in the project areas will be 13.8 million m^3 per year. The estimated volume of nonincremental water demand in 2023 is 5.5 million m^3 per year, reaffirming the intensity of the hardships being encountered by the target household beneficiaries in accessing clean and uninterrupted piped water services. **Table ST-2** summarizes the demand for incremental and nonincremental water in the project areas.

E. Cost-Benefit Analysis

7. The cost-benefit analysis of the project was conducted in accordance with the relevant ADB guidelines.[5] The analysis used cost estimates based on the preliminary engineering design prepared by the Design Institute of the MHCS. The estimated costs and benefits of the project were valued using the *domestic price numeraire*. For the analysis, the shadow price adjustment factors used were taken from a recent Uzbekistan project of a similar nature.[6] The factors used were 1.11 for tradeable goods and services, and 0.80 for unskilled labor. The annualized benefits and costs of the project were assessed over a 30-year period, allowing for a five-year construction period, followed by an operating period of 25 years.

9. **Economic costs**. Capital and recurrent O&M costs, inclusive of physical contingencies but excluding all the transfer payments, i.e., taxes and duties as well as price contingencies, expressed in constant mid-2017 prices, were converted into economic prices by applying the relevant conversion factors.[7] **Table ST-3** presents the derivation of economic costs for the project.

10. **Economic benefits.** The economic benefits of the project were derived mainly from two sources: (i) the incremental water consumption benefits estimated using the willingness to pay of the consumers; and (ii) the nonincremental benefits in terms of resource cost savings as a result of the switch by the targeted household beneficiaries from alternative water sources to piped water. The PSA survey incorporated a willingness to pay survey which determined that households were willing to pay at least SUM5,000/m^3 for accessing improved water services in the project areas.[8] To arrive at an estimate of the incremental water consumption benefits for the project, therefore, the willingness to pay of SUM5,000/m^3 was multiplied by 50 lpcd in 2023, slowly increasing to 120 lpcd by 2040.[9]

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[5] These include the following: (i) Guidelines for the Economic Analysis of Projects (2017), (ii) Economic Analysis of Water Projects (1998), and (iii) Handbook for Integrating Risk Analysis in the Economic Analysis of Projects (2002).

[6] These shadow price adjustment factors are consistent with similar projects of the same nature in Uzbekistan. See for example the *Report and Recommendations of the President to the Board of Directors: Proposed Loan Republic of Uzbekistan: Djizzak Sanitation System Development Project (August 2015).*

[7] In September 2017, the Central Bank of Uzbekistan devalued the SUM by 92.38% to SUM8100=$1. While it has been acknowledged by the Government that this will affect the total project cost, a methodology for estimating the impact of the devaluation on inflation, has yet to be developed and agreed. Bids received on a recent procurement for a similar type international donor-funded project reflected that the estimated contract costs have remained unchanged from the pre-devaluation US$ estimates as of November 2017.

[8] See Annex 10. Poverty and Social Analysis (PSA) Report (June 2017), ADB PPTA 9286 UZB–Western Uzbekistan Water Supply Development Project Feasibility Study.

[9] The PSA survey used a contingent valuation methodology to estimate the willingness to pay of SUM5,000/m^3. The survey indicated that households were willing to pay as much as SUM5,000/m3 because they associated clean, safe, and more reliable water supply with increased employment and livelihood opportunities, considerable public health improvements, and significant resource cost savings.

11. The resource cost savings associated with switching from alternative water sources to piped water through the project were calculated starting initially at SUM5,335/m^3, decreasing gradually to SUM3,092/m^3 by 2040 using the results of the PSA survey. These savings were derived mostly from costs associated with the purchase and consumption of bottled and purified water, hand pumps, and water storage containers.[10] Additional resource cost savings were also determined based on the survey which reported that about 14,500 households, involving mostly women spent an average of 2.75 days per month sourcing water from vendors, pumping stations, hand pump boreholes, public water reservoirs, and water bodies. The economic value of the time spent by these women fetching water outside their homes was calculated by applying a shadow price factor of 0.4 on the weighted average daily income of SUM58,500 in the project areas.[11]

12. The estimated health benefits of the project were based on the survey finding from the PPTA which indicated that residents—whose health was adversely affected by the poor water quality in the region—lost about 15 working days per year.[12] These number of days lost was multiplied by the weighted average daily income in the region and by the number of people affected which according to the PSA reached almost 15,000 annually.

13. **EIRR calculation and sensitivity analysis.** The resulting base case economic internal rate of return (EIRR) is 11.47%, which exceeds the prescribed minimum discount rate of 9% (**Table 1**). This confirms that the project is economically viable, with anticipated economic benefits greater than the estimated economic costs. A sensitivity analysis, undertaken to further test economic viability, ascertained that the project will remain economically robust under the following scenarios: (i) a 10% increase in investment cost possibly arising from a delayed implementation schedule or higher than expected inflation, (ii) a 10% increase in operations and maintenance costs which can result from higher-than-budgeted personnel salaries and other related costs, (iii) a 10% decline in benefits possibly resulting from lower-than-projected resource cost savings, consumption benefits, and health benefits, (iv) a combination of scenarios (i), (ii), and (iii), and (v) a delay in subproject benefits by a year (**Table 2**). **Table ST-4** provides details on the EIRR estimation while **Table ST-5** summarizes the results of the sensitivity analysis conducted.

14. **Distribution of benefits and poverty impact.** A distribution analysis of the quantified net benefits of the project was also conducted. The major stakeholders of the project include (i) the Government, (ii) labor, and (iii) local households, including those living in the most vulnerable communities in the rural areas outside the city centers of the six selected districts. The analysis confirmed that labor, both skilled and unskilled, and local households stand to gain about $54.8 million or 57.9% of the total estimated $94.6 million project benefits.[13] The poverty impact ratio (PIR) was also calculated for the quantified benefits to determine the impact of the project on the poor households. The calculated PIR is 35.6%. This ratio exceeds the estimated 10% GDP share of the poor in Uzbekistan and confirms that the project has a significant poverty reducing impact.[14]

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[10] Given water supply interruptions that could last for days, households in the project areas found it necessary to invest in water storage containers which can accommodate up to 50 liters of water.

[11] See PSA Report (June 2017), ADB PPTA 9286 UZB.

[12] The PSA survey confirmed the increasing incidence of the following diseases in the project areas: (i) gastrointestinal diseases, (ii) typhoid fever,(iii) urolithiasis diseases, (iv) genitourinary diseases, and (v) musculoskeletal diseases. The prevalence of infectious diseases in Karakalpakstan as a result of inadequate supply, and poor quality of water is cited in many studies and project reports. See for example, World Bank. "Project Performance Assessment Report, Uzbekistan Water Supply, Sanitation, and Health Project (Loan 4261), 2015."

[13] Calculated using net present values based on a discount rate of 9%.

[14] There is no available data on the GDP share of the poor in Uzbekistan. In this case, the suggested rule of thumb is 10% (see ADB, Handbook for Integrating Poverty Impact Assessment in Economic Analysis, 2001).

Table ST-6 shows the detailed distribution of benefits analysis and the calculation of the poverty impact ratio (PIR) of the project.

Table 1: Summary Cost-Benefit Analysis ($'000)

Year	Economic Costs		Economic Benefits			Net Benefits
	Capital Cost	Incremental O&M	Resource Cost Savings from Switching to Piped Water	Incremental Water Consumption	Health Benefits	
2018	693					(693)
2019	15,269					(15,269)
2020	39,735					(39,735)
2021	38,594					(38,594)
2022	37,657					(37,657)
2023	3,899					(3,899)
2024		1,257	8,206	7,856	3,362	18,167
2025		1,257	8,064	9,190	3,396	19.393
2026		1,257	7,921	11,181	3,430	21,275
2027		1,257	7,779	12,595	3,464	22,582
2028		1,257	7,637	12,770	3,499	22,649
2029		1,257	7,494	12,947	3,534	22,719
2030		1,257	7,352	13,127	3,569	22,791
2031		1,257	7,210	13,975	3,605	23,533
2032		1,257	7,067	14,169	3,641	23,620
2033		1,257	6,925	14,366	3,677	23,712
2034		1,257	6,783	14,565	3,714	23,806
2035		1,257	6,641	15,471	3,751	24,606
2036		1,257	6,498	15,686	3,789	24,717
2037		1,257	6,356	15,905	3,827	24,831
2038		1,257	6,214	16,126	3,865	24,948
2039		1,257	6,128	16,351	3,904	25,126
2040		1,257	6,071	18,086	3,943	26,843
2041		1,257	6,014	18,338	3,982	27,078
2042		1,257	5,929	18,593	4,022	27,288
2043		1,257	5,787	18,853	4,062	27,445
					EIRR =	11.47%
					NPV at 9%=	25,501

EIRR=economic internal rate of return; O&M = operation and maintenance;
Source: Asian Development Bank estimates.

Table 2: Economic Evaluation and Sensitivity Analysis

Scenario	EIRR (%)	NPV (in $'000)	Switching Value ($'000)	Sensitivity Indicator
Base Case	11.47	25,501		
Case 1: 10% increase in capital cost	10.43	15,670	23.62	4.23
Case 2: 10 % increase in O&M	11.41	24,830	401.29	0.25
Case 3: 10 % decrease in benefits	10.28	12,741	20.68	4.54
Case 4: 10 % increase in capital cost 10% decrease in benefits	9.18	1,948		
Case 5: delay in project benefits by 1 year	10.11	11,912		

EIRR = economic internal rate of return; NPV = net present value; O&M = operation and maintenance

Annex A
Supplementary Tables

Supplementary Table ST-1: Population Projections

	Year >>>>>	0	5	7	9	11	13	15	16	17	19	21	23	25
	ITEM	2017	2023	2025	2027	2029	2031	2033	2034	2035	2037	2039	2041	2043
1	**Amudarya District**													
	Mangit District Center	35,179	38,511	39,691	40,907	42,160	43,451	44,782	45,463	46,154	47,568	49,025	50,526	52,074
	Settlements Outside District Center	44,603	48,828	50,324	51,865	53,454	55,092	56,779	57,642	58,518	60,311	62,158	64,062	66,024
	Total Amudarya District	79,782	87,340	90,015	92,772	95,614	98,543	101,561	103,105	104,672	107,878	111,183	114,588	118,098
2	**Beruniy District**													
	Beruniy District Center	59,697	65,856	68,047	70,312	72,651	75,068	77,566	78,846	80,147	82,813	85,569	88,416	91,358
	Settlements Outside District Center	37,823	41,725	43,114	44,548	46,030	47,562	49,144	49,955	50,779	52,469	54,215	56,019	57,883
	Total Beruniy Center	97,520	107,582	111,161	114,860	118,681	122,630	126,710	128,801	130,926	135,282	139,784	144,434	149,240
3	**Karauzak District**													
	Karauzak District Center	15,302	16,634	17,103	17,585	18,081	18,590	19,115	19,382	19,653	20,208	20,777	21,363	21,966
	Settlements Outside District Center	16,479	17,912	18,417	18,936	19,470	20,019	20,584	20,872	21,164	21,761	22,374	23,005	23,654
	Total Karauzak Center	31,781	34,546	35,520	36,521	37,551	38,610	39,698	40,254	40,818	41,969	43,152	44,369	45,620
4	**Kungrad District**													
	Kungrad District Center	67,521	72,530	74,281	76,075	77,912	79,793	81,719	82,700	83,692	85,713	87,782	89,902	92,072
	Settlements Outside District Center	28,494	30,608	31,347	32,104	32,879	33,673	34,486	34,900	35,318	36,171	37,044	37,939	38,855
	Total Kungrad District	96,015	103,138	105,628	108,179	110,791	113,466	116,205	117,600	119,011	121,884	124,827	127,841	130,927
5	**Nukus District**													
	Akmangit District Center	9,772	10,404	10,623	10,847	11,076	11,310	11,549	11,670	11,793	12,042	12,296	12,556	12,821
	Settlements Outside District Center	23,628	25,156	25,687	26,229	26,783	27,348	27,925	28,219	28,515	29,117	29,732	30,359	31,000
	Total Nukus District	33,399	35,559	36,310	37,076	37,859	38,658	39,474	39,889	40,308	41,159	42,027	42,915	43,821
6	**Muynak District**													
	Muynak District Center	13,350	14,171	14,456	14,747	15,043	15,346	15,654	15,811	15,969	16,290	16,617	16,951	17,292
	Settlements Outside District Center	10,570	11,220	11,445	11,675	11,910	12,150	12,394	12,518	12,643	12,897	13,156	13,421	13,690
	Total Muynak District	23,920	25,391	25,902	26,422	26,953	27,495	28,048	28,328	28,612	29,187	29,773	30,372	30,982
	Total Project Population	**362,416**	**393,556**	**404,536**	**415,831**	**427,449**	**439,402**	**451,697**	**457,977**	**464,346**	**477,359**	**490,746**	**504,519**	**518,688**
	Urban	200,820	218,106	224,202	230,472	236,923	243,559	250,385	253,872	257,408	264,633	272,066	279,714	287,582
	Rural	161,595	175,449	180,334	185,358	190,527	195,843	201,312	204,105	206,938	212,726	218,680	224,805	231,106

Source: Design Institute under the Ministry of Housing and Communal Services, June 2017.

Supplementary Table ST-2: Incremental and Nonincremental Demand for Water, 2023-2042

Description	Units	2023	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Population in Project Area	people	393,556	410,143	415,831	421,599	427,449	433,383	439,402	445,506	451,697	457,977	464,346	470,806	477,359	484,005	490,746	497,583	504,519	511,553	518,688
Serviced Population (w piped water)	people	144,041	150,112	152,194	154,305	156,446	158,618	160,821	163,055	165,321	167,619	169,951	172,315	174,713	177,146	179,613	182,116	184,654	187,228	189,840
Water Demand WITHOUT PROJECT 1/																				
Total Domestic Consumption (A)	lpcd	30.70	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00
Total Institutional Demand (5% of A)	lpcd	1.54	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
Total Commercial Demand (8% of A)	lpcd	2.46	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Total	lpcd	34.69	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03
Water Demand WITHOUT PROJECT																				
Total Domestic Consumption	m3/year	4,409,989	4,640,771	4,705,123	4,770,391	4,836,589	4,903,730	4,971,829	5,040,898	5,110,953	5,182,007	5,254,075	5,327,173	5,401,314	5,476,515	5,552,790	5,630,156	5,708,629	5,788,224	5,868,958
Total Institutional Demand (5% of A)	m3/year	220,499	232,039	235,256	238,520	241,829	245,187	248,591	252,045	255,548	259,100	262,704	266,359	270,066	273,826	277,640	281,508	285,431	289,411	293,448
Total Commercial Demand (8% of A)	m3/year	352,799	371,262	376,410	381,631	386,927	392,298	397,746	403,272	408,876	414,561	420,326	426,174	432,105	438,121	444,223	450,413	456,690	463,058	469,517
Total	m3/year	4,983,288	5,244,071	5,316,789	5,390,542	5,465,346	5,541,215	5,618,166	5,696,215	5,775,376	5,855,668	5,937,105	6,019,705	6,103,485	6,188,462	6,274,653	6,362,077	6,450,751	6,540,693	6,631,923
Water Demand WITH PROJECT																				
Nonincremental Domestic Consumption 2/	lpcd	27.0	27.0	27.3	27.5	27.0	27.3	27.5	27.0	27.3	27.5	27.0	27.3	27.5	27.0	27.3	27.5	27.0	27.3	27.5
Nonincremental Domestic Consumption	m3/day	10,626	10,626	10,732	10,840	10,626	10,732	10,840	10,626	10,732	10,840	10,626	10,732	10,840	10,626	10,732	10,840	10,626	10,732	10,840
Incremental Domestic Consumption (B)	lpcd	50	80	100	100	100	100	105	105	105	105	110	110	110	110	110	120	120	120	120
Incremental Domestic Consumption (C)	m3/day	12,476	20,802	26,364	26,729	27,100	27,476	29,251	29,657	30,069	30,488	32,383	32,834	33,291	33,754	34,225	37,856	38,384	38,919	39,462
Incremental Institutional Demand (5% of B)	lpcd	3	4	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6
Incremental Institutional Demand (5% of C)	m3/day	624	1,040	1,318	1,336	1,355	1,374	1,463	1,483	1,503	1,524	1,619	1,642	1,665	1,688	1,711	1,893	1,919	1,946	1,973
Incremental Commercial Demand (8% of (B)	lpcd	4	6	8	8	8	8	8	8	8	8	9	9	9	9	9	10	10	10	10
Incremental Commercial Demand (8% of C)	m3/day	998	1,664	2,109	2,138	2,168	2,198	2,340	2,373	2,406	2,439	2,591	2,627	2,663	2,700	2,738	3,028	3,071	3,114	3,157
Total Water Production WITH PROJECT (allowing for Unaccounted for Water)																				
Nonincremental Domestic Water	m3/year	5,492,548	5,577,014	5,639,352	5,702,413	5,648,684	5,712,042	5,776,139	5,723,461	5,787,886	5,853,064	5,801,484	5,867,022	5,933,331	5,882,896	5,949,598	6,017,087	5,967,850	6,035,767	6,104,488
Incremental Domestic Water	m3/year	4,553,637	7,592,900	9,622,735	9,756,219	9,891,605	10,028,919	10,676,601	10,824,922	10,975,359	11,127,942	11,819,974	11,984,420	12,151,214	12,320,392	12,491,987	13,817,494	14,010,080	14,205,422	14,403,560
Incremental Institutional Demand	m3/year	502,309	658,496	763,104	772,932	777,014	787,048	822,637	827,419	838,162	849,050	881,073	892,572	904,227	910,164	922,079	991,729	998,897	1,012,059	1,025,402
Incremental Commercial Demand	m3/year	803,695	1,053,593	1,220,967	1,236,691	1,243,223	1,259,277	1,316,219	1,323,871	1,341,060	1,358,480	1,409,717	1,428,115	1,446,764	1,456,263	1,475,327	1,586,766	1,598,234	1,619,295	1,640,644
Water Losses as % of Demand	%	30%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Water Losses	m3/year	2,039,566	1,822,276	1,905,856	1,928,009	1,917,230	1,939,592	1,978,749	1,968,688	1,991,777	2,015,149	2,023,068	2,046,927	2,071,080	2,062,331	2,086,751	2,148,896	2,141,245	2,166,780	2,192,634
Total		13,391,755	16,704,279	19,152,014	19,396,263	19,477,756	19,726,878	20,570,345	20,668,360	20,934,243	21,203,686	21,935,316	22,219,057	22,506,616	22,632,047	22,925,743	24,561,972	24,716,307	25,039,324	25,366,728
Total Consumption WITH PROJECT																				
Nonincremental Water Sales	m3/year	3,878,492	3,878,492	3,917,277	3,956,450	3,878,492	3,917,277	3,956,450	3,878,492	3,917,277	3,956,450	3,878,492	3,917,277	3,956,450	3,878,492	3,917,277	3,956,450	3,878,492	3,917,277	3,956,450
Incremental Domestic Water Consumption	m3/year	4,553,637	7,592,900	9,622,735	9,756,219	9,891,605	10,028,919	10,676,601	10,824,922	10,975,359	11,127,942	11,819,974	11,984,420	12,151,214	12,320,392	12,491,987	13,817,494	14,010,080	14,205,422	14,403,560
Incremental Institutional Water Consumption	m3/year	502,309	658,496	763,104	772,932	777,014	787,048	822,637	827,419	838,162	849,050	881,073	892,572	904,227	910,164	922,079	991,729	998,897	1,012,059	1,025,402
Incremental Commercial Water Consumption	m3/year	803,695	1,053,593	1,220,967	1,236,691	1,243,223	1,259,277	1,316,219	1,323,871	1,341,060	1,358,480	1,409,717	1,428,115	1,446,764	1,456,263	1,475,327	1,586,766	1,598,234	1,619,295	1,640,644
Total (With Project Less Without Project)		9,738,133	13,183,481	15,524,083	15,722,291	15,790,334	15,992,521	16,771,907	16,854,704	17,071,857	17,291,922	17,989,256	18,222,384	18,458,655	18,565,311	18,806,670	20,352,439	20,485,703	20,754,054	21,026,056

Supplementary Table ST-3: Derivation of Economic Costs

INVESTMENT COSTS (Constant 2017 prices, in US$ '000)

PROJECT COST ITEM	TOTAL FINANCIAL	FINANCIAL WITHOUT TAX	FINANCIAL COSTS EXCLUDING TAX								TOTAL ECONOMIC COSTS
			Unskilled Labor		Skilled Labor		Local Materials		Tradeables		
			%	Total	%	Total	%	Total	%	Total	
A. Civil Works											
1. Water Treatment Plants	17,450	14,542	10%	1454	20%	2908	20%	2908	50%	7271	15,059
2. Water Distribution Centers	15,870	13,225	10%	1323	20%	2645	20%	2645	50%	6613	13,695
3. Network Pipelines	88,990	74,158	10%	7416	20%	14832	20%	14832	50%	37079	76,795
4. Household Connections	9,020	7,517	10%	752	20%	1503	20%	1503	50%	3758	7,784
5. Detailed Engineeering Design	1,470	1,225	10%	123	20%	245	20%	245	50%	613	1,269
6. Nonrevenue Water Control	460	383	10%	38	20%	77	20%	77	50%	192	397
Subtotal Civil Works	**133,260**	**111,050**	**10%**	**11,067**	**20%**	**22,133**	**20%**	**22,133**	**51%**	**55,333**	**114,601**
B. Equipment and Machinery											
1. Equipment WTPs	4,680	3,900	0%	0	0%	0	30%	1170	70%	2730	4,203
2. Equipment District WSSs	5,440	4,533	0%	0	0%	0	40%	1813	60%	2720	4,836
3. Equipment Nonrevenue Water Control	1,340	1,117	0%	0	0%	0	20%	223	80%	893	1,216
4. Utility Machineries and Equipment	1,560	1,300	0%	0	0%	0	40%	520	60%	780	1,387
Subtotal Equipment and Machinery	**13,020**	**10,850**	**0%**	**0**	**0%**	**0**	**34%**	**3,727**	**66%**	**7,123**	**11,641**
C. Project Implementation Support											
1. Project Management	240	200	0%	0	70%	140	30%	60	0%	0	200
2. Consulting Services	3,350	2,792	0%	0	30%	838	10%	279	60%	1675	2,978
3. Project Financial Audit	140	117	0%	0	20%	23	20%	23	60%	70	124
4. Environmental Management	80	67	0%	0	100%	67	0%	0	0%	0	67
5. Social Safeguards	100	83	0%	0	100%	83	0%	0	0%	0	83
Subtotal Equipment and Machinery	**3,910**	**3,258**	**10%**	**0**	**20%**	**652**	**30%**	**978**	**40%**	**1303**	**3,452**
D. Training, Studies and Capacity Building											
1. Corporate Development Program	890	742	0%	0	30%	223	20%	148	50%	371	783
2. O&M Capacity Development	840	700	0%	0	30%	210	20%	140	50%	350	739
3. GIS Hydraulic Model	490	408	0%	0	40%	163	10%	41	50%	204	431
4. Rural Sanitation and Hygiene Improvement	600	500	0%	0	50%	250	20%	100	30%	150	517
Subtotal Consulting Services	**2,820**	**2,350**	**0%**	**0**	**36%**	**846**	**18%**	**429**	**46%**	**1,075**	**2,469**
Total BASELINE COSTS	**153,010**	**127,508**	**10%**	**11,067**	**19%**	**23,631**	**21%**	**27,267**	**51%**	**64,835**	**132,165**
Physical Contingencies	4,290	3,575	9%	322	20%	715	28%	1,001	43%	1,537	3,681
TOTAL PROJECT COSTS	**157,300**	**131,083**	**9%**	**11,388**	**19%**	**24,346**	**22%**	**28,268**	**51%**	**66,372**	**135,846**

1.03633377

RECURRENT COSTS (Constants 2017 prices, in US$ '000)

PROJECT COST ITEM	TOTAL FINANCIAL	FINANCIAL WITHOUT TAX	FINANCIAL COSTS EXCLUDING TAX								TOTAL ECONOMIC COSTS
			Unskilled Labor		Skilled Labor		Local Materials		Foreign Costs		
			%	Total	%	Total	%	Total	%	Total	
1. Operations & Maintenance (2023-2042)	1,455	1,213									**1,257**

Supplementary Table ST-4: Economic Internal Rate of Return Calculation

	Economic Costs(US$'000)		Economic Benefits (US$'000)			
Year	Incremental Capital Cost	Incremental Operation & Maintenance	Nonincremental Water Consumption	Incremental Water Consumption	Incremental Health Benefits	incremental Net Benefits
2018	693	-	-	-	-	(693)
2019	15,269	-	-	-	-	(15,269)
2020	39,735	-	-	-	-	(39,735)
2021	38,594	-	-	-	-	(38,594)
2022	37,657	-	-	-	-	(37,657)
2023	3,899	-	-	-	-	(3,899)
2024	-	1,257	8,206	7,856	3,362	18,167
2025	-	1,257	8,064	9,190	3,396	19,393
2026	-	1,257	7,921	11,181	3,430	21,275
2027	-	1,257	7,779	12,595	3,464	22,582
2028	-	1,257	7,637	12,770	3,499	22,649
2029	-	1,257	7,494	12,947	3,534	22,719
2030	-	1,257	7,352	13,127	3,569	22,791
2031	-	1,257	7,210	13,975	3,605	23,533
2032	-	1,257	7,067	14,169	3,641	23,620
2033	-	1,257	6,925	14,366	3,677	23,712
2034	-	1,257	6,783	14,565	3,714	23,806
2035	-	1,257	6,641	15,471	3,751	24,606
2036	-	1,257	6,498	15,686	3,789	24,717
2037	-	1,257	6,356	15,905	3,827	24,831
2038	-	1,257	6,214	16,126	3,865	24,948
2039	-	1,257	6,128	16,351	3,904	25,126
2040	-	1,257	6,071	18,086	3,943	26,843
2041	-	1,257	6,014	18,338	3,982	27,078
2042	-	1,257	5,929	18,593	4,022	27,288
2043	-	1,257	5,787	18,853	4,062	27,445
					11.47%	

Supplementary Table ST-5: EIRR Calculation and Summary Sensitivity Analysis (US$'000)

Sensitivity Analysis Scenarios	
Case 1:	10% Increase in Capital Cost
Case 2:	10% Increase in O & M
Case 3:	10 % decrease in benefits
Case 4:	10 % increase in capital costs + O&M; 10 % decrease in benefits
Case 5:	delay in project benefits by one year

	NET BENEFITS (US$'000)					
Year	Base Case	Case 1	Case 2	Case 3	Case 4	Case 5
2018	(693)	(762)	(693)	(693)	(762)	(693)
2019	(15,269)	(16,796)	(15,269)	(15,269)	(16,796)	(15,269)
2020	(39,735)	(43,708)	(39,735)	(39,735)	(43,708)	(39,735)
2021	(38,594)	(42,453)	(38,594)	(38,594)	(42,453)	(38,594)
2022	(37,657)	(41,422)	(37,657)	(37,657)	(41,422)	(37,657)
2023	(3,899)	(4,289)	(3,899)	(3,899)	(4,289)	(3,899)
2024	18,167	18,167	18,042	16,225	16,099	(1,257)
2025	19,393	19,393	19,267	17,328	17,202	18,167
2026	21,275	21,275	21,150	19,022	18,896	19,393
2027	22,582	22,582	22,456	20,198	20,072	21,275
2028	22,649	22,649	22,523	20,258	20,133	22,582
2029	22,719	22,719	22,593	20,321	20,196	22,649
2030	22,791	22,791	22,666	20,387	20,261	22,719
2031	23,533	23,533	23,407	21,054	20,928	22,791
2032	23,620	23,620	23,495	21,133	21,007	23,533
2033	23,712	23,712	23,586	21,215	21,089	23,620
2034	23,806	23,806	23,680	21,299	21,174	23,712
2035	24,606	24,606	24,481	22,020	21,894	23,806
2036	24,717	24,717	24,591	22,119	21,994	24,606
2037	24,831	24,831	24,705	22,222	22,096	24,717
2038	24,948	24,948	24,822	22,328	22,202	24,831
2039	25,126	25,126	25,000	22,488	22,362	24,948
2040	26,843	26,843	26,717	24,033	23,907	25,126
2041	27,078	27,078	26,952	24,244	24,119	26,843
2042	27,288	27,288	27,162	24,433	24,308	27,078
2043	27,445	27,445	27,445	27,445	24,701	27,288
EIRR	**11.47%**	**10.43%**	**11.41%**	**10.28%**	**9.18%**	**10.11%**
NPV	**25,501**	**15,670**	**24,830**	**12,741**	**1,948**	**11,912**
SV		**23.62**	**401.29**	**20.68**		
SI		**4.23**	**0.25**	**4.84**		

Supplementary Table ST-6: Distribution of Benefits and Poverty Impact Ratio (US$'000)

Present Values at 9% discount rate

A. Distribution of Project Effects	Financial Returns (1)	Economic Returns (2)	Difference (2) - (1)	Economy/ Government	Labor	Local Households	Total
Output	50,459	127,597	77,137	26,998	15,427	34,712	77,137
Capital costs	(113,844)	(98,310)	15,534	11,340	4,194		15,534
Operating costs	(8,632)	(6,706)	1,927	1,406	520		1,927
Total costs	(122,476)	(105,016)	17,460	12,746	4,714		17,460
Net Economic Returns	(72,017)	22,581	94,598	39,744	20,142	34,712	94,598
B. Poverty Impact Ratio Calculation				**Economy/ Government**	**Labor**	**Local Households**	**Total**
Net Economic Returns				39,744	20,142	34,712	94,598
Financial Returns				(72,017)			(72,017)
Benefits				3,387	6,097	13,097	22,581
Percentage of Poor				15.0	27.0	45.0	
Benefits to the Poor				508	1,646	5,894	8,048
Poverty Impact Ratio							**35.6%**