ECONOMIC ANALYSIS

A. Introduction

1. Khyber Pakhtukhwa Province (KPK) is one of the four administrative provinces of Pakistan and accounts for about 11% of Pakistan’s gross domestic product. Since 2005, KPK recorded the fastest annual growth rate—about 5%—among Pakistan's four provinces. KPK has a population of about 32 million, which is projected to reach about 58 million by 2035.[1] By the same year, it is estimated that 35% of KPK’s population will be concentrated in cities, up from 16% in 2017. Basic urban services such as water supply, wastewater collection and treatment, stormwater drainage, solid waste management (SWM), and green urban spaces (e.g., parks) have failed to meet increasing urban domestic and commercial demand, leading to gradual degradation of the urban environment and living standards. In 2015, the government of KPK established seven water and sanitation services companies (WSSCs) to take over utility management from local government institutions. The WSSCs are still in their initial years of operation and lack sufficient financial, technical, and physical resources to optimize their operational effectiveness. The project will improve the quality of life of residents living in five cities of KPK: Abbottabad, Kohat, Mardan, Mingora, and Peshawar. This will be achieved by addressing urban development challenges at the municipal level, including integrated planning, improved urban infrastructure and services, and improved operation and maintenance (O&M) capacity for water supply, sanitation, SWM, and urban green space management.

B. Demand Analysis

2. The project will have three Outputs: (i) climate resilient and gender-friendly urban infrastructure improved; (ii) institutional capacity and gender inclusiveness of urban service providers, provincial government, and city governments strengthened; and (iii) women’s participation in urban governance and access to economic opportunities increased. Output 1 comprises a water supply and sanitation subproject which includes water supply component, sewerage and drainage components, SWM component, and green urban infrastructure components. The green urban infrastructure component will support the rehabilitation of seven existing green spaces and nature trails; improvement of pedestrian sidewalks and streets; and conversion of one existing landfill to a park.

3. **Water supply component**. Piped water supply is severely limited in KPK. Poor maintenance and leakage contribute to significant losses from piped water networks and contamination of the water supply. Nonrevenue water (NRW) is predicted to increase over time as water pipes gradually deteriorate.[2] The average clean water supply capacity of the WSSCs in Abbottabad, Kohat, Mingora, and Peshawar, where the water supply component will be implemented, is 238,443 cubic meters (m^3) per day, translating to 40 liters per capita per day (lpcd) of piped water to 247,000 people for an average of 6 hours a day. Households augment their water supply with alternative sources to reach up to 100 lpcd. Alternative sources include groundwater from private boreholes, government filtration plants, bottled water, and water carts, which are not only more expensive but also cause significant health consequences. With the project, each WSSCs will have the capacity to supply up to 400,000 m^3 per day of clean water, translating to 132.5 lpcd for 800,000 people for the four cities starting in 2028. Household meters will be installed and a gradual increase in volumetric water tariffs will be introduced through

[1] Government of Pakistan. 2017. Population Census. Islamabad.
[2] In the absence of accurate information on the project area, it is assumed that most NRW comprises a technical loss.

reforms.[3]

4. **Sewerage and drainage component**. Operational sewerage systems serve less than 5% of KPK. Where networks exist, they are poorly maintained and prone to overflow, causing floods. In Mardan and Kohat, where the sewerage and drainage component of the water supply and sanitation subproject will be implemented, wastewater moves via open drains, and there are no functional wastewater treatment plants. Wastewater and sewage are discharged untreated into surface water drains, or onto farmland to be used for irrigation, which poses a significant health risk to local farmers and communities. ADB site visits to the Mardan and Kohat project areas revealed no functional waste sedimentation ponds or wastewater treatment plants. The project assumes that the 2021 baseline capacity for proper waste treatment is zero, increasing to 30,000 cubic meters of sewage daily starting in 2027 with the construction of two new treatment plants. With the project, 180,000 people will be served by a 156 km sewerage network connected to the new wastewater treatment system. This improvement will reduce the high incidence of water-borne diseases such as diarrhea and lung and skin infections, as well as prevent malaria, dengue, and hepatitis.[4]

5. **Solid waste management component**. SWM in KPK is poor because of a lack of proper infrastructure and equipment and weak management and technical capacity. Less than 30% of municipal solid waste is collected; uncollected waste is typically burned, disposed of in drains, or used to fill low-lying land. Pakistan is one of the top 10 countries with the highest mismanagement of plastic waste in the Asia and Pacific region.[5] Cities in KPK are highly polluted, with high volumes of plastic waste ending up in rivers and drains. Since there are no large-scale, properly engineered sanitary landfills, collected waste is disposed of in open dumps, which lack controls to mitigate pollution of the surrounding environment. Mostly large trash containers are provided in areas under WSSC control. Thus, the 2021 baseline in all five project cities is zero SWM facilities, no solid waste treatment, and no door-to-door solid waste collection. With the project, 2,000 tons of solid waste will be treated daily, benefitting 1,807,400 people, starting in 2028. Through reduced burning and proper waste treatment, the project will contribute to reduced greenhouse gas (GHG) emissions of 176,370 tons of carbon dioxide equivalent per year.

C. Alternative Analysis

6. Detailed technical feasibility studies and engineering designs for civil works were prepared through ADB project readiness financing using integrated urban design principles. Many alternative design approaches were considered for the water supply, sewerage and drainage, and SWM components and presented in the project's Situational Analysis Report (February 2020).[6] For the water and sanitation subproject which includes sewerage and drainage components, in all cases the alternatives were rehabilitation of existing infrastructure or building new infrastructure, with a combination of these found to be the least-cost approach, taking into account climate resilience and safeguard considerations. For the water supply component, a conventional treatment process was found to be the least-cost method of treating raw water for potable use.[7]

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[3] Households under the purview of a given WSSC pay a monthly flat rate of PRs200–PRs370 per month, which covers water, wastewater, and solid waste management.

[4] M. K. Daud et al. 2017. Drinking Water Quality Status and Contamination in Pakistan. *BioMed Research International*, Vol. 2017, 3. Article ID 7908183; and Khyber Pakhtunkhwa Cities Improvement Project Baseline Socio-Economic Survey (June 2021).

[5] Laurent C. M. LeBreton, Boyan Slat.2017. *River Plastic Emissions to the World Oceans. New York.*

[6] Creative Engineering Consultants and Minconsult. 2020. Khyber Pakhtunkhwa Cities Improvement Project Situational Analysis Report.

[7] This comprises coagulation, flocculation, and filtration, followed by disinfection.

For the sewerage and drainage component, conventional activated sludge processes, with primary and secondary treatments, have been adopted as the optimal design for biological treatment. Various waste diversion, resource recovery, and energy capture techniques were assessed for the SWM component based on waste volume, physio-chemical characteristics of waste, land requirements, technical complexities, and O&M considerations. Final designs are based on a combination of mechanical biological treatment techniques including material recovery, recycling, refuse-derived fuels, anaerobic digestion, and composting. Landfill site selection and design were guided by technical assessments that included review of international best practices; consultation with local communities; assessment of geology, surface, and subsurface hydrology; and environmental considerations and climate change considerations. Selected engineering designs, screening, and evaluation of priority projects, including costing, is in the situational analysis and project memorandum of understanding.

D. Cost–Benefit Analysis

7. **Economic costs.** Total costs for outputs 1, 2, and 3 were subjected to economic analysis in accordance with ADB guidelines.[8] Costs were prorated and distributed among the water supply component, sewerage and drainage component, SWM, and green urban infrastructure components of output 1 (Table 1). Physical contingencies are included but price contingencies, financial charges, taxes, and duties are excluded. Economic costs of capital works and annual O&M are calculated from project cost estimates by distinguishing traded and nontraded goods; a shadow exchange rate factor of 1.039 was applied to traded goods and a shadow wage rate factor of 0.869 was applied to unskilled labor.[9] The economic opportunity cost of capital is assumed at 9% in real terms. All costs are based on constant 2021 prices converted at €1.00 = PRs185.98. Analysis was conducted from 2022 to 2051, including 5 years of construction and 25 years of economic life.

Table 1: Details of Project Costs
(€ million)

	Capital Costs		O&M Costs			
Components	**Financial Cost**	**Economic Cost[a]**	**Financial Cost**	**Economic Cost**	**Construction**	**O&M**
Water supply	232.95	204.30	8.20	7.12	June 2022–May 2026. Full operational in 2027	June 2028–May 2051
Sewerage and drainage	91.70	80.53	3.23	2.80		
Solid waste management	194.2	166.68	6.86	5.95		
Urban space	25.50	21.51	0.90	0.78		
Total	**545.08**	**473.02**				

O&M = operation and maintenance.
[a] Excludes taxes and duties, price contingencies, and financial charges.
Source: Asian Development Bank estimates.

8. **Economic benefits.** For water supply component, the economic benefits assumed were (i) avoided earnings loss during sick days, (ii) avoided treatment of waterborne disease, and (iii) willingness to pay (WTP) for incremental water consumed. For the sewerage and drainage component, the benefits assumed were (i) avoided earnings loss during flood days, (ii) avoided infrastructure damage from floods, (iii) avoided earnings loss during sick days, (iv) avoided cost of treatment of waterborne diseases, and (v) avoided cost of wastewater treatment. For SWM,

[8] ADB. 2017. *Guidelines for the Economic Analysis of Projects.* Manila.
[9] ADB. 2017. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Administration of Loan to the Islamic Republic of Pakistan for the Peshawar Sustainable Bus Rapid Transit Corridor Project.* Manila.

economic benefits were valued using (i) reduction in GHG emission, (ii) time saved for trash disposal, and (iii) WTP for improved SWM (Table 2).[10] Conservatively, costs associated with urban green spaces were included but economic benefits were not estimated because the component accounted for only 4.5% of total project costs.

Table 2: Economic Benefits
(PRs million)

Category	Unit Rate PRs/HH/Yr	Total Benefits (PRs million)—2028		
		Water Supply	Sewerage	Solid Waste
A. Non-incremental benefits				
Avoided cost of treatment of waterborne diseases[a]	7,828	564	10	
Avoided earnings loss during sick days[b]	113,668	8,196	144	
Avoided earnings loss during flood days[c]	41,376		131	
Avoided damage to infrastructure from floods[d]	74,824		238	
Time saved for trash disposal[e]	3,060			2,442
Avoided cost of wastewater treatment[f]	103,685		329	
Reduction in GHG emissions[g]				1,446
B. Incremental benefits				
WTP for incremental water consumed[h]	297			
WTP for improved solid waste management[i]				5,496

GHG = greenhouse gas, HH = household, WTP = willingness to pay.

[a] Treatment costs for waterborne diseases estimated at PRs32,814 (annual cost of treatment for diseases from survey) x 0.43 (of total treatment costs are attributed to waterborne disease) x 55.1% (number of households affected by waterborne disease). Because both untreated sewage and contaminated drinking water cause disease, 60% of the unit cost for treatment is ascribed to contaminated water supply and 40% is ascribed to poor sewerage and drainage, thus avoiding double counting. (Source: Khyber Pakhtunkhwa Cities Improvement Project (KPCIP) Baseline Socio-Economic Survey, 2021).

[b] Avoided earnings loss during sick days from waterborne diseases estimated at PRs7,233 (average daily HH income based on KPCIP Socioeconomic Survey 2021) x 15.7 days (average annual working days lost due to waterborne disease); 40% of this loss was ascribed to poor sewerage and 60% was ascribed to contaminated water supply based on the survey. The project team confirms that there is no double counting of non-incremental benefits between sewerage and water supply. Source: KPCIP Baseline Socio-Economic Survey, 2021).

[c] Avoided earnings loss during flood days estimated at PRs7,233 (average daily HH income, estimated using data on per capita income) x 5.72 days (average annual working days lost because of floods) (Source: KPCIP Baseline Socio-Economic Survey, 2021).

[d.] Cost of avoidance of damage to infrastructure estimated at PRs27,300 (average cost of repair and maintenance works after each flood) x 2.74 flooding frequency per year (Source: KPCIP Baseline Socio-Economic Survey, 2021).

[e] Time saved for trash disposal estimated at 30 minutes daily for a women or child, at PRs 216,000 (annual salary of an unskilled worker) x shadow wage rate (0.85) and reduced to efficiency factor of 0.8 (child/girl/women) (Source: Baseline Socio-Economic Survey, 2021; and Government of Pakistan Ministry of Finance assigned minimum salary of unskilled worker).

[f] Avoided cost of wastewater treatment estimated assuming that wastewater produced per household in KPK is 431.5 cubic meters (m^3) per year, against project-enabled sewage treatment capacity increase of 11,096,000 m^3 sewage per year, and cost of wastewater treatment at 0.21 € per year in 2010 updated to 2021 prices assuming using traditional sedimentation method. Source: KPCIP estimates; G. Murtaza and M. H. Zia. 2012. Wastewater Production, Treatment and Use in Pakistan. Final Country Report. Pakistan.

[g] Total annual reduction in GHG emission of 176,370 tons of carbon dioxide equivalent (tCO^2e) x €36.4/ tCO^2e (year 2020) increased at 2.23% per annum, the average value of world gross domestic product deflators for the last 3 years (Source: World Bank national accounts data, and Organisation for Economic Co-operation and Development national accounts data files).

[h] Benefits transfer method using unit transfer approach was used. Source: A. Akram and S. M. Olmstead. 2011. The Value of Household Water Service Quality in Lahore, Pakistan. *Environmental and Resource Economics*. Vol 49, Issue 2, page 173–198. (WTP from 2011 was updated to 2021 using consumer price index.)

[i] Benefits transfer method using unit transfer approach was used. Source: U. Mustafa, I. Ahmad, and M. ul Haq. 2014. Capturing Willingness to pay and its Determinants for Improved Solid Waste Management. *Pakistan Institute of Development Economics Working Papers No 110:* Pakistan: PIDE. (WTP from 2014 was updated to 2021 using

[10] Households who will avail of services are assumed to pay for SWM based on WTP, replacing current flat rate.

consumer price index). The WTP survey introduced efficiency, regularity, and sanitary improvements but omitted time saved for trash disposal, hence minor time saved was included as a non-incremental benefit.
Source: ADB

9. **Results of cost–benefit analysis**. The with- and without-project scenarios were compared. Results of the cost–benefit analysis show that the project is economically viable because all three components and the project overall exceed ADB's threshold of 9% for economic viability. The economic internal rate of return (EIRR) for the water supply component is 13.1%, 10.1% for the sewerage and drainage component, and 19.3% for SWM component. The overall EIRR is 14.1%. Table 3 summarizes the base case real EIRR and net present value for the components and the overall project. The overall NPV for the project is PRs31,958 million.

Table 3: Summary of Economic Viability

Subproject	EIRR %	ENPV @ 9% PRs million	ENPV @ 9% € million
Water supply	13.1	12,649	68.01
Sewerage and drainage	10.1	1,839	9.89
Solid waste management	19.3	16,096	86.55
Overall	**14.1**	**30,584**	164.45

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

10. **Affordability.** WTP for urban services in KPK is low. WTP, which for water supply and SWM is assumed to be the monthly tariff, is PRs206/month for water supply (about 0.09% of the average monthly household income in KPK, which is estimated at PRs217,000) and PRs573/month for SWM (0.26% of the average monthly household income). This demonstrates the affordability of the water tariff for all income categories, considering that allocation of 5.0% of monthly household income for utilities is generally acceptable. [11]

11. **Sensitivity analysis.** The base case was subjected to sensitivity analysis to assess the effects of adverse changes in key variables on benefits, including (i) a 10% overrun in capital (ii) a 10% overrun in O&M costs, (iii) a 10% decrease in net benefits, and (iv) a 1-year delay in operation and (v) implementation delayed by 3 years. The results, including switching values, are in Table 4. Sensitivity analysis shows that overall, the project is most sensitive to a combined worst scenario.

Table 4: Economic Internal Rate of Return and Sensitivity Analysis
(PRs million)

	Combined			Water Supply Component			Sewerage and Drainage Component			Solid Waste Management Component		
	EIRR	NPV	SV	EIRR	NPV	SV	EIRR	NPV	SV	EIRR	NPV	SV
Base case	14.4	30,584		13.1	12,649		10.1	1,839		19.3	86.5	
Capital cost (+10%)	12.7	23,494	43.1	11.9	9,556	40.9	9.4	748	16.8	17.1	70.9	55.4
O&M cost (+10%)	13.8	27,837	111.3	12.7	11,451	105.6	10.1	1,749	203.7	18.9	78.7	110.3
Benefit (- 10%)	12.2	17,688	23.7	11.4	7,093	22.8	9.3	473	13.5	16.5	54.4	26.9
Delay in operation by one year	14.1	30,476		13.0	12,140		9.9	1,374		19.4	91.2	
3-year delay in implementation	14.0	31,732		12.8	9,203		9.2	343		19.5	108.4	

EIRR = economic internal rate of return, NPV = net present value, SV = switching value.
Source: ADB

[11] Government of Punjab, Housing, Urban Development and Public Health Department. 2013. Pakistan: Water Supply and Sanitation Sector. Punjab.