ECONOMIC ANALYSIS

A. Approach and Methodology

1. Economic analysis was conducted for batch 1, stage 1 subprojects (water supply, sanitation, drainage, solid waste, roads, bridges, and cyclone shelters). Economic analysis for batch 1, stage 2 and batch 2, stages 1 and 2, will be undertaken once the relevant subproject scopes have been defined. The subprojects in batch 2 towns are likely to generate similar returns as batch 1 towns, because the towns face similar challenges and have similar needs.

2. For subprojects with quantifiable economic benefits and costs, the economic internal rate of return (EIRR) was calculated and compared to the estimated economic opportunity cost of capital (12%) for three scenarios: (i) present situation—without project, (ii) project investment—without future climate resilience measures (CRM), and (iii) project investment—with CRM.[1] The subproject life is assumed to be 20 years with salvage values. The analysis is based on domestic numeraire in April 2013 constant prices. A shadow wage factor of 0.94 and a shadow exchange factor of 1.07 are applied to convert financial values to economic values using ADB economic analysis guidelines (footnote 1).[2] Population projections for each *pourashava* (secondary town) are based on historical trends.

B. Economic Analysis

3. The overall EIRR is 23% for batch 1, stage 1. All of the proposed subprojects with future CRMs have a positive present value and an EIRR above 12%, the economic opportunity cost of capital (EOCC). Sensitivity analysis also shows robust results. All subprojects proposed for batch 1-stage 1 are economically viable and the additional cost of climate change adaptation is justified based on the calculation of economic benefits.

1. Water Supply Subprojects

4. The economic benefits of the water supply subprojects in each *pourashava* are calculated using the resource cost savings on non-incremental water consumption by switching from alternative sources to piped water.[3] Resource cost savings also include labor for hauling water, storage tank installation, boiling water for drinking purposes and water purchased from private vendors.[4]

5. **Water supply with future climate resilience measures**. EIRRs with future CRMs are slightly higher (or equal) to EIRRs without future CRMs. However, the present value of benefits with future CRM is significantly higher than without CRM and justifies the additional adaptation costs.[5]

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[1] Economic analysis was carried out in accordance with ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila. and ADB. 1998. *Guidelines for the Economic Analysis of Water supply Projects*. Manila. The methodology for calculating climate resilience project benefits is available upon request.

[2] Factors based on Government of Bangladesh, Ministry of Finance. 2012. *Bangladesh Economic Review 2011*. Dhaka.

[3] Alternative sources include pond sand filters, public stand posts, tanker supply and bottled water.

[4] Project preparatory technical assistance (PPTA) survey data was used for *pourashava*-specific costs and average time spent fetching water. Time spent is valued at the unskilled labor wage rate (BDT375/day) for all *pourashavas*.

[5] Detailed economic analysis tables, including all assumptions, are available upon request. Summary tables and a description of main assumptions are included in the list of linked documents in Appendix 2 of RRP.

Table 1: Water Supply Subproject Benefits, Economic Internal Rates of Return, and Sensitivity of Results with Climate Resilience Measures

Pourashava	Present Value of Benefits	EIRR Base	Sensitivity (%)				
	BDT million	%	Cap. Cost +20%	O&M Cost +20%	Benefit –20%	Worst Case	1-Year Delay
Amtali	168.6	17.7%	14.9%	17.1%	14.8%	12.0%	17.4%
Galachipa	107.3	14.0%	11.6%	13.7%	11.8%	9.5%	13.8%
Mathbaria	343.9	15.3%	12.6%	15.2%	13.0%	10.5%	15.1%
Total	**619.8**						

BDT = Bangladeshi Taka, Cap. = capital, CRM = climate resilience measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

6. **Amtali water supply**. Current piped water supply coverage is 39% (1,296 household connections). Coverage will reach 60% with the project (1,916 additional households) and consumption is estimated at 100 liters per capita per day (lpcd) for connected households**.** Most households prefer private connections and the mean willingness-to-pay (WTP) for improved services is BDT226 ($2.90) per month.[6] The proposed volumetric water tariff is BDT15 per cubic meter (m^3) (a 50% increase) by the completion of works in 2016, with periodic revisions every 4 years of 15% in real terms from FY2022 to FY2042**.**[7] The estimated base case EIRR is 17.7%, and the result is robust when subjected to sensitivity analysis.

7. **Galachipa water supply**. Current piped water supply coverage is 39% (2,050 households) and consumption is estimated at 100 lpcd for connected households. Most households prefer private connections and the mean WTP for improved services is BDT156.8 ($2.00) per month (footnote 7). The proposed volumetric water tariff is BDT12/m^3 (a 20% increase) by the completion of works in 2016 with periodic revisions every 4 years of 5% in real terms from FY2022 to FY2042. The estimated base case EIRR is 14.0% and the result is robust when subjected to sensitivity analysis.

8. **Mathbaria water supply**. The project will introduce a new piped water supply system with a coverage target of 80% or 4,000 households. Average consumption is estimated at 100 lpcd. Most households prefer private connections and the mean WTP for improved services is BDT186.5 ($2.40) per month (footnote7). The proposed volumetric water tariff is BDT15/m^3 by completion of works in 2016 with periodic revisions every 4 years of 10% in real terms from FY2022 to FY2042. The estimated EIRR for the base case is 15.3% and the result is acceptable when subjected to sensitivity analysis.

2. Drainage Subprojects

9. **Valuation of benefits**.[8] Property damage benefits in all four *pourashavas* have been assessed based on construction, repair and clean-up costs for each type of property likely to be affected by floods in the "without project" situation.[9] Projected inundation levels and

[6] May 2013 prices. Source: ADB. 2013. *Final Report: Technical Assistance to the People's Republic of Bangladesh for Preparing the Coastal Towns Infrastructure Improvement Project.* Manila.

[7] See Supplementary Economic Appendix (accessible from the list of linked documents in Appendix 2).

[8] For cost–benefit analysis the cost of all proposed solid waste subprojects (equipment purchase only) has been combined with drainage subprojects because of the former's relatively low cost and the strong linkages with drainage (e.g. ensuring that solid waste does not clog drains).

[9] Prices used: BDT1,200 per square foot (ft^2) for shacks (*katcha*), and 1,600/ft^2 for semi-permanent (*semi-pakka*) and 2,000/ft^2 for permanent (*pakka*) structures. Repair costs are estimated at 6% of construction costs. Clean up costs used are BDT2,000 ($25.64), for *katcha, BDT5,000 ($64.10) for semi-pakka* and *BDT9,000 ($115.38) pakka* structures, based on ADB. 2013. Final Report: Capacity Development Technical Assistance to the Government of Bangladesh for *Strengthening the Resilience of the Urban Water Supply, Drainage, and Sanitation to Climate Change in Coastal Towns*. Manila.

average building area of the affected properties were estimated and considered in the technical design and economic analysis.[10] The benefits associated with damage and repairs were estimated on the 5% of properties projected to be inundated by more than 0.25 meters. Clean-up cost benefits were estimated for all properties likely to be inundated. An increase in income benefit was estimated based on the number of households likely to be affected and the number of days of flooding. Reduced medical cost benefits were estimated based on average household expenditures on treatment for waterborne diseases and the number of households likely to be affected by flooding. Agricultural crop losses as a result of flooding have been estimated based on land area, average yield and market price of crops.[11] Reduced road damage benefits were assessed based on the kilometers of road likely to be flooded and the associated repair costs that may be avoided.

10. **Drainage with future climate resilience measures.** The EIRRs for the "with" and "without" CRM projects do not vary significantly. However, the present value of projects with CRM is significantly higher than those without CRM, which justifies the additional adaptation costs.

Table 2: Drainage Economic Internal Rate of Return and Sensitivity Results of Project *Pourashavas* with Climate Resilience Measures

Town	Present Value Benefits	EIRR Base	Sensitivity (%)				
			Capital Cost +20%	O&M Cost +20%	Economic Benefit –20%	Cost +20% & Benefit –20%	1-Year Delay
	BDT million	(%)					
Amtali	81.9	26.4	22.3	26.3	21.3	17.7	26.4
Galachipa	327.2	18.1	14.9	18.0	14.1	11.3	17.9
Pirojpur	944.1	42.9	36.6	42.8	35.2	29.9	42.8
Mathbaria	342.6	33.9	28.8	33.8	27.6	23.3	33.8
Total	**1,696.8**						

BDT = Bangladeshi Taka, CRM = climate resilience measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

a. Drainage subprojects in each *pourashava*

11. Table 3 summarizes the proposed length of drainage and associated benefits.

Table 3: Summary of Drainage Subprojects and Benefits in Batch 1 *Pourashavas*

	Amtali	Galachipa	Mathbaria	Pirojpur	Total
Drainage – proposed length (km)	2.45	10.28	10.8	25.14	**48.7**
	Benefits				
No. properties	680	2,018	1,840	8,906	**13,444**
No. households[a]	239	2,287	861	10,670	**14,057**
Avoided losses to agricultural land (km^2)	0.3	0.65	0.5	7.37	**8.8**
Avoided damage to roads (km)	2	2	6	15	**25.0**

km = kilometers, km^2 = square kilometers.
[a] The quantified benefits to households are (i) avoided loss of income, and (ii) savings in medical costs.
Source: Asian Development Bank estimates.

3. Sanitation Subprojects

12. Table 4 summarizes the sanitation subprojects in each batch 1 p*ourashava*.

Table 4: Summary of Sanitation Subproject in Batch 1 *Pourashavas*

No.	Amtali	Galachipa	Mathbaria	Pirojpur	Total
Community latrines	11	11	9	1	**32**
Public toilets	2	5	4	0	**11**
School latrines	0	3	7	0	**10**

[10] Data from Mathbaria and Pirojpur are used to determine the average floor space of different types of buildings.
[11] Average support price assumed at BDT17,500 ($224.36) per ton, based on project preparatory TA data.

No.	Amtali	Galachipa	Mathbaria	Pirojpur	Total
Desludging machines	1	2	2	2	**7**
Sludge management facility	1	1	1	1	**4**
Beneficiaries (households/day)	555	2,310	2,195	1,425	**6,485**

Source: Asian Development Bank estimates.

13. The main benefits expected from sanitation subprojects are (i) an increase in income, and (ii) reduced medical costs based on a reduction in the number of sick days attributed to improper or inadequate sanitation.[12] Sanitation subprojects without CRM would only achieve 80% of the estimated medical cost savings of the projects with CRM. Both EIRRs and present values of projects with future CRM are higher than for projects without future CRM.

Table 5: Sanitation Economic Internal Rate of Return and Sensitivity Results of Project *Pourashavas* with Climate Resilience Measures

Town	Present Value of Benefits	EIRR Base	Sensitivity (%)				
	BDT million	(%)	Capital Cost + 20%	O&M Cost +20%	Economic Benefit –20%	Cost +20% & Benefit –20%	1-Year Delay
Amtali	19.8	14.2	11.7	13.3	10.1	7.0	14.0
Galachipa	79.7	25.0	21.3	23.8	19.2	15.0	24.9
Pirojpur	62.8	27.9	23.9	26.8	21.8	17.4	27.9
Mathbaria	78.8	30.0	25.7	28.8	23.6	19.0	29.9
Total	**241.1**						

BDT = Bangladeshi taka, CRM = climate resilience measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

4. Road Subprojects

14. **Valuation of benefits.** Two main benefits are envisaged: (i) vehicle operating cost (VOC) savings;[13] and (ii) an increase in income, because improved project roads result in decreased commuting time.[14] In addition, CRM will help to decrease the flood-related damage to roads.[15]

15. The EIRRs for road subprojects with future CRM are all above 12% EOCC. The present value of benefits is higher with CRM than without CRM, because the latter does not have the benefits of avoiding road damage.

Table 6: Road Economic Internal Rate of Return and Sensitivity Results of Project *Pourashavas* with Climate Resilience Measures

Town	Sub-project	Present Value of Benefits	EIRR Base	Sensitivity (%)				
	Road improvements (km)	BDT (million)	(%)	Capital Cost + 20%	O&M Cost +20%	Economic Benefit -20%	Cost +20% & Benefit –20%	1-Year Delay
Amtali	9.7	202.9	24.7	17.3	20.4	16.3	13.2	20.5
Galachipa	7.5	168.8	20.9	17.4	20.7	16.5	13.3	20.8
Pirojpur	31.9	503.6	21.4	18.0	21.3	17.1	16.1	21.3
Mathbaria	8	181.1	20.3	17.0	20.1	16.1	15.2	20.2

[12] Average monthly household income is BDT13,841 ($177.45). Monthly household expenditure on health costs is BDT1,097 ($14.06); 30% of this is attributed to sanitation-related problems. A reduction of 2.5 days per year of sick days related to sanitation is assumed for each household (project preparatory TA socioeconomic survey).
[13] VOC savings per vehicle are based on an estimated number of vehicles on project roads and savings of BDT10 for cars, BDT4 for three-wheel vehicles (auto rickshaw), BDT1.5 for two-wheel vehicles, BDT13 for buses, and BDT16 for trucks (project preparatory TA technical estimate).
[14] Income benefits for *pourashavas* are based on average time savings and average monthly household income.
[15] Damage-related benefits are based on 2013 estimated construction costs with an annual 2% real increase.

Total	**49.1**	**1,056.4**

BDT = Bangladeshi taka, CRM = climate resilient measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

5. Bridge Subprojects

16. Four bridges are proposed in Pirojpur; and one bridge in Mathbaria. The number and category of vehicles to use these bridges has been estimated. Two main benefits are envisaged: (i) VOC savings (footnote 13), and (ii) increased income because of reduced commute time.[16] At present only non-motorized vehicles cross the bridges because of the low load capacity. The scenario without future CRM accrues just 75% of the benefits of scenario with CRM. The EIRRs of bridge subprojects with CRM are well above the 12% EOCC.

Table 7: Bridges Economic Internal Rate of Return and Sensitivity Results of Project *Pourashavas* with Climate Resilience Measures

Town	Present Value of Benefits	EIRR Base	Sensitivity (%)				
	BDT (million)	(%)	Capital Cost + 20%	O&M Cost +20%	Economic Benefit –20%	Cost +20% & Benefit –20%	1-Year Delay
Pirojpur	31.7	21.1	17.8	21.1	17.1	14.2	21.0
Mathbaria	41.2	22.2	18.8	22.2	18.1	15.1	22.1

BDT = Bangladeshi Taka, CRM = climate resilience measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

6. Cyclone Shelters Subprojects

17. The project proposes to construct three cyclone shelters with a capacity of 1,200 persons each in Amtali; three cyclone shelters with a capacity of 1,300 persons each in Galachipa; one cyclone shelter with a capacity of 2,000 persons in Mathbaria; and five cyclone shelters with a capacity of 1,300 persons each in Pirojpur.

18. **Valuation of benefits**. The climate change models used in the technical analysis estimate an additional two cyclones per year in the project area. The main economic benefits of the cyclone shelters are: an increase in income and reduced medical costs resulting from reduced number of days of sickness attributed to improper or inadequate sanitation.[17]

Table 8: Cyclone Shelter Economic Internal Rate of Return and Sensitivity Results of Project *Pourashavas* with Climate Resilience Measures

Town	Present Value of Benefits	EIRR Base	Sensitivity (%)				
	BDT (million)	(%)	Capital Cost + 20%	O&M Cost +20%	Economic Benefit –20%	Cost +20% & Benefit –20%	1-Year Delay
Amtali	90.7	16.5	13.7	16.4	13.0	10.5	16.3
Galachipa	94.0	17.1	14.2	17.1	13.6	11.0	16.9
Pirojpur	177.0	19.3	16.2	19.2	15.5	12.7	19.1
Mathbaria	69.9	35.0	30.1	35.0	29.0	24.8	35.0

BDT = Bangladeshi Taka, CRM = climate resilience measures, EIRR = economic internal rate of return, O&M = operations and maintenance.
Source: Asian Development Bank estimates.

[16] Time savings are assumed to be nine minutes, and earnings per km are assumed to be BDT15 based on an average monthly household income of BDT 14,620 ($187.44) in Pirojpur (project preparatory TA socioeconomic survey).
[17] Saved expenditure on health is BDT 1,097 ($14.06) per household.