INFRASTRUCTURE,

ENERGY, AND INDUSTRY

JAMUNA BRIDGE RAILWAY LINK PROJECT

I. Background of the Project

The transport system of Bangladesh consists of roads, railways, inland waterways, ports, and civil aviation. Roads carry about 65 percent of inter-district passenger movements and 45 percent of the freight. Bangladesh Railway (BR) carries about 20 percent of the passenger traffic and about 10 percent of the freight. Inland waterways account for the remaining portion of land transport. The share of civil aviation in total transport is relatively negligible. While road transport has grown to dominate the movement of short-haul traffic, BR is increasingly concentrating its efforts on long-haul transport, particularly freight movements and inter-city passenger traffic. Moreover, there are gradual shifts in trade patterns toward intra-country freight movements, particularly between Chittagong and Dhaka and the northwest part of the country. It is expected that this traffic will increase manifold after the opening of the Jamuna Bridge and add pressure to the existing transport network.

In Bangladesh, the railway plays an important role for long-distance freight such as bulk and containers, and inter-city passenger traffic. This is particularly true on the most important arterial corridor between Dhaka and Chittagong and the northwest region of the country which carries most traffic. Indian transit traffic carried by BR continues to increase and the freight demand cannot be fully met by BR. This traffic could increase considerably as a result of more subregional cooperation and the opening of new district strategic corridors between Bangladesh, Bhutan, India and Nepal and more Indian transit traffic between West Bengal and the eastern states of India. Transport intensities are expected to increase substantially over the coming years, as the country continues to move from an inward-oriented to an outward-oriented economy. A higher modal share for railways in the expected increase in heavy freight traffic is highly desirable and would be less costly to the overall economy.

Despite relatively low road traffic intensity, Bangladesh has a higher incidence of road traffic accidents and fatalities than other comparable countries in Asia. Environment friendly transport technology and energy efficient systems are called for to prevent further increases in environmental damage, improve safety, and save energy. In this context, the railway also has an important role to play, being the least energy intensive and polluting mode—as well as the safest and least demanding of land for comparable expansions in capacity.

II. Project Details

The main objectives of the Project are to: (i) remove BR's critical bottleneck at the Jamuna River ferry crossing; (ii) optimize the utilization of the Jamuna Bridge; (iii) integrate, rationalize, and improve the railway system by connecting the west and east railway networks including better integration of the two different gauges; (iv) promote continued restructuring and institutional reforms in BR through commercialization of operations and implementation of market-oriented policies; (v) contribute to the physical and economic integration of the less developed northwestern region with the more developed eastern region of the country; and (vi) improve existing opportunities and create new ones for the opening of new subregional rail transport corridors among Bangladesh, Bhutan, India, and Nepal. The project area can be seen in the map.

Given the extreme scarcity of agricultural land in Bangladesh, several innovations ensure that the Project has the minimum possible impact on good land. It is estimated that 640 ha of land will be consumed by the new railway alignment once the entire Project is finished. According to a survey conducted by the BR, 4,300 structures and 1,173 households will be affected by the alignment running through their properties—homesteads or agricultural holdings. On the eastern side of the Jamuna River, the alignment will pass a forest plantation. A detailed resettlement/compensation scheme will be instituted. All lands, structures, and crops sacrificed for the project—either permanently or during construction—will be compensated for. However, the need to cut trees will be minimized. Special engineering

Map
Bangladesh Jamuna Bridge Railway Link Project

works will be installed to minimize disruption to fish, and to mitigate undue fishing pressure at certain locations.

The Project cost is estimated at $269 million, 41 percent of which is ADB-financed.

III. Analytical Methods

The economic analysis of environmental impacts requires a comparison of the Project viability against the "without-Project" situation. The Project will lead to increased transportation of freight and people via rail, and it will lessen volumes in the alternative forms of transport—specifically road transport. It is estimated that the Project will reduce transit time between Dhaka and points west of the river by as much as four hours. The Project leads to avoided costs due to a reduction in emissions compared to the current emissions of alternative forms of transportation.

The economic analysis of environmental impacts is carried out in four stages: in the first stage, avoided stressors or pollutants are identified and quantified. The quantification is based on the estimated reduction in fuel consumption of shifting the transport of commodities from trucks to freight trains. Based on the initial environmental examination (IEE) which is shown in Appendix 5, a shift in the mode of transport from road to rail reduces fossil fuel consumption by 0.006 liters per ton-kilometer. Using standard technical coefficients, the reduced fuel consumption was translated into avoided amounts of TSP, CO, SO_2, NO_x and CO_2 (Final Report, TA 1414: Vehicular Emissions Control Planning in Metro Manila, 1992). In the second stage, impact screening is carried out for each stressor. If the impacts are major, then in the third stage, an attempt is made to place monetary values on the impacts using the benefits-transfer method (BTM). Finally, these values are integrated into the economic analysis of the Project. A qualitative valuation of potential environmental impacts of the Project is also presented based on the IEE. The IEE provides a partial quantification in terms of loss of agricultural land and crop loss which are integrated into the economic analysis.

IV. Economic Valuation of Environmental Impacts

Table 1 shows the amount of avoided stressors. The Project would lead to avoided environmental emissions such as CO, SO_2, NO_x, CO_2 and various other particulate matters.

Table 1: Avoided Environmental Emissions
(in metric tons)

Stressor	Annual Average	Total Over the Life of the Project
TSP	*94.98*	*2,374.60*
CO	*50.66*	*1,266.45*
SO_2	*56.99*	*1,426.76*
NO_x	*140.37*	*3,509.13*
CO_2	*185.75*	*4,643.65*

TSP = total suspended particulates; CO = carbon monoxide; SO_2 *= sulfur dioxide;*
NO_X *= nitrogen oxides;* CO_2 *= carbon dioxide.*

In the second stage, these stressors are screened for their potential impacts on four major groups: human health, human welfare, environmental resources, and global systems, as reflected in Table 2.

Table 2: Environmental Emissions and their Potential Impacts

	Human Health			Human Welfare			Environmental Resources		Global Systems
Stressor	Mortality	Morbidity	Materials	Resource Use	Social/ Cultural	Coastal Marine	Ground Water	Bio-diversity	
TSP	x	x	x	x					
CO	x	x							
SO_2	x	x	x	x	x				
NO_x	x	x	x		x				
CO_2									x
Noise		x			x			x	
Accidents	x	x			x				

TSP = total suspended particulates; CO = carbon monoxide; SO_2 *= sulfur dioxide;*
NO_X *= nitrogen oxides;* CO_2 *= carbon dioxide.*

Out of the various impacts, the following impacts are significant and they are described as follows:

A. Human Health Impacts

Increased Morbidity and Mortality from Air Emissions. Health studies currently focus on airborne particles that are small enough to be inhaled deeply into the lungs (called PM_{10}). PM_{10} aerosols resulting from the combustion of fossil fuels include sulfate and nitrate aerosols, acid aerosols, and other chemical constituents. Their impacts include both premature mortality and chronic acute respiratory disease.

Accidental Death. Incidents of accidental death are generally lower in railways than other forms of transportation.

Noise. Noise and vibration affect morbidity if extensive zones conflict with living areas. These zones include line traffic, terminal areas and marshaling yards. Morbidity effects of noise and vibration include discomfort and headaches.

B. Human Welfare Impacts

Visibility Impacts from Air Emissions. Particulate matter (less than 2.5 microns in diameter) that is emitted directly from industries or is formed in the presence of sulfur dioxide and nitrogen oxide gas emissions can reduce visual range.

Building and Materials Impacts. Particulate matter and acid deposition from sulfur dioxide emissions can damage materials. Materials damage can include surface soiling, surface erosion, blistering, paint discoloration, corrosion and tarnishing of metals and electronic components, fading, reduction of fabric tensile strength, and spalling of buildings and monuments.

Aesthetic, Social/Cultural Value and Biodiversity Impacts. Noise decreases aesthetic value and has social/cultural impacts. Noise may affect biodiversity by altering species habitat and corridors.

C. Global Impact

It is well recognized that environmental impacts are not confined to the immediate location, or even at the country level, but involve impacts on the global level. It has already been noted that the Project will improve the local environment through avoided SO_2, NO_x, TSP and other emissions. The Project will also lead to avoided CO_2 emissions (by about 185.75 t/yr), and the economic value of CO_2 was assessed using IPCC figures. Avoided CO_2 is considered a benefit to the global environment whereas other avoided environmental emissions benefit local areas.

D. Valuation

Once the major environmental impacts and their influence on human health, human welfare and socioeconomic activities are properly identified, the analysis can proceed to the third stage wherein such impacts are given economic value. There are various methods available for such valuations and some of the methods require substantial amount of primary data, time and field investigations. Thus BTM was used for this assessment. BTM allows the use of results from similar valuations conducted in different parts of the world with proper adjustments to any particular project.

Table 3 summarizes the adjusted values for environmental impacts of air pollutants based on ADB's *Economic Evaluation of Environmental Impacts: A Workbook*. While adjusting the data from the results of original research in the United States (US) to Bangladesh, three major adjustments were carried out for: (i) GDP differentials between the US and Bangladesh, (ii) population differentials between the US and Bangladesh, and (iii) updating the price level to 1996 constant prices. For inflation adjustments, the GDP deflator of Bangladesh was used. All assumptions regarding physical quantities of environmental emissions are consistent with the underlying assumptions made for the economic analysis.

Table 3: Original and Adjusted Unit Values of Air Pollutants for Economic Analysis

Impact	Original Unit Value (1992 $/t)	Adjusted Unit Value (1996 $/t)
Human health and welfare impacts:		
TSP (PM_{10})	*3,000-5,000*	*897.39-1,495.63*
Human health and welfare impacts:		
SO_2	*750-1,300*	*224.35-388.86*
Human health and welfare impacts:		
No_x	*1,000-2,000*	*299.13-598.25*
Global impacts: CO_2	*8.64-20.03*	*no adjustment needed*

TSP = total suspended particulates; PM_{10} = particulate matter less than 10 microns; SO_2 = sulfur dioxide; NO_X = nitrogen oxides; CO_2 = carbon dioxide.

V. Notable Aspects

For the economic valuation of environmental impacts both high and low unit values were used. Two cases—with- and without-project net present values (NPVs)—were calculated using two alternative discount rates of 10 and 12 percent. The results are given in Table 4 below. The integrated NPV with environmental impacts are higher than the without-environmental impacts NPV, implying that the project design leads to improvements in the overall environmental conditions in the project location. The detailed environmental economic analysis is found in Table 5.

Table 4: Summary of Economic Analysis of Environmental Impacts
($ million)

	Net Environmental Benefits	
	Low Value	High Value
Net present value @ 10%	*8.75*	*19.25*
Net present value @ 12%	*7.55*	*16.61*

Table 5: Avoided Environmental Cost due to Reduced Emissions
($'000)

Year	PM_{10}		SO_2		NO_X		CO_2		Total	
	Low	High	Low	High	Low	High	Low	High	Low	High
1997	–	–	–	–	–	–	–	–	–	–
1998	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	–	–	–	–	–	–	–
2000	–	–	–	–	–	–	–	–	–	–
2001	24.0	36.3	3.3	5.7	10.7	21.5	410.6	923.3	448.6	986.8
2002	45.6	69.1	6.2	10.8	20.4	40.9	781.0	1,756.4	853.3	1,877.1
2003	54.6	82.7	7.4	12.9	24.4	48.9	934.3	2,101.1	1,020.8	2,245.5
2004	64.1	97.1	8.7	15.1	28.7	57.4	1,096.7	2,466.3	1,198.2	2,635.9
2005	67.0	101.4	9.1	15.8	30.0	60.0	1,146.0	2,577.1	1,252.0	2,754.3
2006	70.0	106.0	9.5	16.5	31.3	62.6	1,197.1	2,692.0	1,307.9	2,877.1
2007	72.9	110.5	9.9	17.2	32.7	65.3	1,248.1	2,806.9	1,363.7	2,999.9
2008	76.0	115.2	10.4	18.0	34.0	68.1	1,301.1	2,925.9	1,421.5	3,127.1
2009	79.2	120.0	10.8	18.7	35.5	70.9	1,355.8	3,049.0	1,481.3	3,258.7
2010	82.4	124.9	11.2	19.5	36.9	73.8	1,410.6	3,172.1	1,541.1	3,390.3
2011	85.8	130.0	11.7	20.3	38.4	76.9	1,513.1	3,405.4	1,649.1	3,632.6
2012	89.4	135.4	12.2	21.1	40.0	80.0	1,575.2	3,545.0	1,716.7	3,781.5
2013	92.9	140.7	12.7	22.0	41.6	83.2	1,637.2	3,684.6	1,784.3	3,930.4
2014	96.6	146.3	13.2	22.8	43.3	86.5	1,703.0	3,832.7	1,856.0	4,088.4
2015	100.5	152.2	13.7	23.7	45.0	89.9	1,770.7	3,985.0	1,929.8	4,250.8
2016	104.4	158.1	14.2	24.7	46.7	93.5	1,840.2	4,141.5	2,005.6	4,417.8
2017	108.5	164.3	14.8	25.6	48.6	97.1	1,911.6	4,302.3	2,083.4	4,589.3
2018	112.7	170.7	15.4	26.6	50.5	100.9	1,986.8	4,471.5	2,165.4	4,769.8
2019	117.1	177.4	16.0	27.7	52.4	104.8	2,063.9	4,644.9	2,249.4	4,954.8
2020	121.6	184.1	16.6	28.7	54.4	108.9	2,142.8	4,822.6	2,335.4	5,144.3
2021	126.2	191.1	17.2	29.8	56.5	113.0	2,221.2	4,997.0	2,421.0	5,330.8
2022	130.8	198.2	17.8	30.9	58.6	117.2	2,303.8	5,182.9	2,511.0	5,529.1
2023	135.8	205.6	18.5	32.1	60.8	121.6	2,390.1	5,377.2	2,605.2	5,736.4
2024	140.9	213.4	19.2	33.3	63.1	126.1	2,480.3	5,579.9	2,703.4	5,952.7
2025	145.8	220.8	19.9	34.5	65.3	130.5	2,566.6	5,774.2	2,797.5	6,160.0
NPV @10%									$8,745.41	$19,249.70
NPV @12%									$7,545.67	$16,607.97

PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide;
NO_X = nitrogen oxides; CO_2 = carbon dioxide.

Note: Another set of estimates were derived using the study of Lars Hansson entitled "Towards Sustainable Transportation-Going from Mere Words to Practice," 1996. The difference in estimated external effects of road and rail traffic was applied to the diverted volume of traffic from - the road due to the Project. The values were adjusted for income level and population density differentials between Bangladesh and Sweden and brought to 1996 prices using the Bangladesh GDP deflator. Since Hansson includes among external costs: traffic accidents, noise costs, wear and tear and air pollution, we used only about 45 percent of the estimated external cost which represents air pollution. The values obtained were NPVs of $38.3 million and 33.09 million at 10 percent and 12 percent discount rates, respectively.

The Project's economic internal rate of return (EIRR) was computed at 19 percent when all other benefits (including environmental benefits) are considered. The exclusion of environmental and global benefits results in an EIRR value of 17.3 percent.

Several aspects of this Project warrant comments. The first, is an illustration of how improvements in one form of transportation can shift total transportation services and therefore provide important environmental benefits both locally as well as globally. By enhancing the competitiveness of rail transport vis-à-vis other forms, the economy becomes more reliant on energy-efficient transportation modes. Benefits are estimated for reduced air pollution using the BTM. The replacement of road transport with rail transport will also improve the overall safety of the transport sector in Bangladesh.

A second interesting aspect of this Project is the extent to which it is designed so as to reduce the environmental implications of its construction and operation. Given the extreme scarcity of good agricultural land in the project area, great care is taken to minimize the displacement of farmers. In fact, when the marshaling yard is removed at the old Jamuna River bridge, the restoration of this area to agriculture will mean that arable land in the project area will not diminish at all.

Third, the improved rail link will be a more environmentally sound transport system, which can enhance economic development in this part of Bangladesh.

Finally, the construction of the Project entails an important element for replacing trees that are sacrificed to the new road bed, and for enhancing protection of fish habitat around the necessary engineering works.

It is important to note that overall environmental impacts are significantly higher than those estimated here. There are many other environmental impacts which were excluded from the economic analysis due to methodological difficulties or lack of data; only the likely impacts (positive or negative) are indicated in Table 6. Therefore, estimated economic benefits of environmental impacts need to be taken as lower bounds rather than optimistic figures.

Table 6: Qualitative Evaluation of Potential Environmental Impacts

Impact	Likely Impact on Net Benefits	Comments
Encroachment on precious ecology/natural forest	–	*No significant adverse effect.*
Impact on fisheries/aquatic ecology and other beneficial water uses	–	*Possible restriction on fish movements. Small adverse effect.*
Encroachment on historical/ cultural sites	–	*None. No significant adverse effect.*
Erosion and siltation	–	*Mainly from new line construction. Small adverse effect.*
Aesthetics	–	*Mainly from new line construction. Small adverse effect.*
Noise and vibrations	–	*Mainly during operation; noise will be considerably less compared to road transport. Small adverse effect.*
Water/runoff pollution	–	*Associated mainly with new construction; may damage aquatic ecosystems. Small adverse effect.*
Oil and hazardous spills	–	*Related to train derailments; may be serious; safety measures and track maintenance necessary. Significant adverse effect but with very low probability.*
Impediment to floodwater runoff	–	*Incremental impact from new line construction; adequate bridges/ culverts necessary. Moderate adverse effect but with low probability.*
Injuries/mortality from rail accidents	–	*Related to train derailments/collisions; safety measures and track maintenance necessary, an improvement over road transport. Significant adverse effect but with very low probability.*

This Project includes benefits and costs of environmental impacts in the economic analysis. The estimated environmental benefits (or *avoided costs* due to reduced fossil fuel consumption) were valued according to avoided human health and welfare impacts.