

Quantifying the Health Benefits of the Greater Dhaka Sustainable Urban Transport Corridor Project

Background

Urban growth in Dhaka, Bangladesh, is exacerbating congestion and air pollution in the city. The Asian Development Bank (ADB) is looking for ways to address the stresses associated with these problems. ADB evaluated six transportation corridors in Greater Dhaka on the basis of their potential to support urban development and help establish a mass-transit infrastructure. The most promising transportation corridor is in the northern part of Dhaka's metropolitan area, with 20 percent of its length located within Dhaka City Corporation area and 80 percent located within Tongi and Gazipur Pourashavas area. Bus rapid transit (BRT) was recommended and selected as the best mass-transit mode for this corridor.

Purpose of the Study

The construction of a BRT line in Dhaka, and the concurrent replacement of some existing buses with compressed natural gas buses, will result in air quality improvements. A previous ADB analysis focused only on the economic benefits of the bus rapid transit line: travel-time and operating cost savings and increased land values. That economic analysis, which covered a 30-year evaluation period, estimated benefits equal to a net present value of \$71 million (at a 12 percent discount rate). The ADB analysis did not attempt to estimate the public health benefits that might result from improvements in air quality associated with the BRT project, nor did it attempt to estimate the project's effects on greenhouse gas emissions.

ADB hired Abt Associates Inc. to conduct a study of these topics. Abt's analysis aimed to quantify some of the public health benefits expected to result from the Dhaka BRT project and to assess potential changes in greenhouse gas emissions. This report describes Abt's approach and methods and presents the results of our analysis. Due to limited inputs, these results should be considered illustrative in nature.

Methods

The Abt study is the first effort to monetize the potential public health benefits of the BRT line in Dhaka. Our approach examined two health endpoints that might result from reduced exposure to air pollution: 1) premature mortality in children and adults, and 2) chronic bronchitis in adults. Additionally, we estimated the changes in specific greenhouse gas emissions (carbon dioxide and methane) expected to result from the BRT project.

Abt obtained information from the ADB project preparation report to define the baseline ("without BRT") and control ("with BRT") scenarios. We followed an analytical framework that included estimates of four main components:

- *The change in primary and secondary particulate emissions from "without BRT" to "with BRT" conditions.* We combined measured emissions factors for BRT and non-BRT buses and minibuses with estimates of vehicle-kilometers travelled. In measuring particulate emissions, we focused on fine particulate matter with an aerodynamic diameter less than 2.5 microns (PM_{2.5}). While we could have estimated the changes in

other pollutants, we focused on PM_{2.5} because of its predominance in other benefit-cost analyses of air pollution.

- *The change in ambient concentrations of fine particulate matter resulting from emission changes.* We input the emissions described above, along with meteorology data for the year 2006, into a simplified atmospheric dispersion model that yielded concentration change estimates for primary and secondary PM_{2.5}. The model we selected is applicable for analyzing seasonal and annual air quality for long-term trends and for evaluating “what-if” scenarios. It was extensively applied for sulfur and particulate modeling studies in Asia (including Bangladesh) at the regional, national, and urban scales.
- *The change in health outcomes.* We measured health outcomes by focusing on reductions in premature mortality (typically the most important health endpoint in benefits assessments) and reductions in chronic bronchitis. We selected these endpoints because the weight of scientific evidence supports a likely causal relationship between PM_{2.5} and these health consequences. We included chronic bronchitis as illustrative of the chronic morbidity effect of ambient air pollution. As stated in a recent report, “Overall, the available studies provide evidence that long-term exposure to ambient air pollution in Asia is associated with chronic respiratory illness, reduced lung function, lung cancer, and adverse reproductive outcomes.”¹

To estimate the change in these health outcomes as a result of reductions in air pollution, we looked at *concentration-response* functions from air pollution epidemiology studies. Specifically, we evaluated the empirically estimated relationships between average ambient *concentrations* of particulate matter and the *response* of adverse health effects as reported by epidemiological studies. Where possible, we used information from studies conducted in Bangladesh. Where such data was not available, we used information from the region or other developing countries, or made adjustments to U.S.-based functions.

- *The monetized benefits of avoided morbidity and mortality.* To estimate the value of avoided adverse health outcomes associated with air pollution, we calculated the total number of cases of the targeted health endpoints and then multiplied each by a corresponding unit value. The unit value estimated the cost of a single case of that adverse health endpoint (or, correspondingly, the benefit of avoiding a single case).

We did not estimate benefits for all pollutants and health endpoints, but instead focused our analysis on endpoints where there was sufficient available evidence. Where information was lacking, we made assumptions using information from the literature. Clearly, however, our analysis is limited by the input data we employed, the assumptions we made, the approach we took, and the models we used.

Results

Abt’s analysis found that the construction of a BRT line in Dhaka, Bangladesh, will result in air quality improvements that will, in turn, bring both public health benefits and reductions in overall greenhouse gas emissions. We estimated results for each year from 2014 to 2044.

¹ Health Effects Institute (HEI). 2010. Outdoor Air Pollution and Health in the Developing Countries of Asia: A Comprehensive Review. Report #: Special Report 18, Publication Type: Special Reports.

We estimated a reduction in greenhouse gas emissions of 434,000 metric tons of carbon dioxide (CO₂) equivalents for the entire BRT project evaluation period. These changes will be driven mainly by replacing a portion of the existing diesel fleet with articulated (large-capacity), cleaner compressed natural gas buses.

Combining the reductions in ambient air pollution with the concentration-response functions, background incidence rates, and population estimates, we estimated 798 fewer premature deaths for adults over age 30, 55 fewer premature deaths for children under age five, and 819 fewer cases of chronic bronchitis in adults over age 25. (We did not have information to estimate premature mortality benefits in those aged 5 to 30.) As expected, the health benefits increase over time. This is not surprising, because both emissions reductions and the population benefitting from these reductions are expected to grow between 2014 and 2044. Using our valuation approach, we quantified total undiscounted monetized benefits of \$116 million (2010 U.S. dollars), with a present discounted value of \$9.5 million (2010 U.S. dollars, discounted to 2011 using a 12 percent discount rate).

These results are illustrative and are limited by the assumptions we made and the approach we took. A more complete characterization of the emissions profile for the “without BRT” and “with BRT” conditions would be expected to increase and refine our estimates. In particular, if more information were available on the proposed inspection and maintenance program for the BRT line, the benefits would be expected to increase. Benefits would also be expected to increase if information on concentration-response functions for mortality were available for those aged 5 to 30. Benefits would be expected to decrease, however, if only smaller compressed natural gas buses (rather than diesel buses) are replaced by articulated compressed natural gas buses. Additional environmental and public health benefits associated with the Dhaka bus rapid transit project may be described as more information becomes available.