Low Emission Scenarios Analysis in The Urban Transportation in Dhaka, Bangladesh Using the Co-Benefits Approach

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LOW EMISSION SCENARIOS ANALYSIS IN THE URBAN TRANSPORTATION IN DHAKA, BANGLADESH USING THE CO-BENEFITS APPROACH

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ABSTRACT

This study analyzes two low-emission scenarios of the Dhaka transport sector, including CNG vehicle-fleet and nonmotorized transportation (NMT), using a co-benefits assessment modeling framework based on the A-S-I(Avoid-Shift-Improvement) strategy, which is used to quantify the expected environmental and public health benefits from implementing the proposed scenarios in the transport sector of Dhaka. The avoided emissions, including GHG, $PM_{2.5}$, and other pollutants, are estimated based on the future projection of the CNG-run vehicles' passenger kilometers (PKM) in the transport sector of Dhaka city is calculated. The factors that affect the use of nonmotorized vehicles in Dhaka city are explored in this study. A logistic regression model is developed, and the future PKM of nonmotorized vehicles is forecasted till 2036 based on the willingness level.

KEYWORDS

Co-benefit assessment, CNG policy, Willingness analysis for nonmotorized vehicles, Future projection, Logistic Regression, Health impact analysis

1. INTRODUCTION

Dhaka, the capital city of Bangladesh, has a history dating back more than 400 years.[1]The city of Dhaka's current transportation status is extremely fragile from an environmental standpoint. According to the World Air Quality Report in 2019, the most polluted country is Bangladesh for $PM_{2.5}$ exposure. Dhaka is the second highest polluted city in the world. Due to the metropolitan Dhaka area's rapid urbanization process, high vehicular population growth and mobility, insufficient transportation facilities and policies, lack of a dependable public transportation system, and ineffective traffic management practices, traffic and environmental issues have significantly worsened. In this study, the first scenario analyzes the climate benefits of the CNG fuel transition in Dhaka's transportation sector using the co-benefit assessment tool (ASIF methodology). Future projections of the CNG fuel-run vehicle population and its associated emissions have been projected based on historical data from the Dhaka transportation industry. Vehicle kilometer of CNG fuel-run vehicles is assessed to 2050 as well. The second scenario involves investigating the current state of NMT utilization based on residents of Dhaka City's willingness to utilize nonmotorized vehicles and the influences of socioeconomic factors, travel characteristics, required trips, and optional excursions (such as those for shopping and recreation) on this willingness. Finally, this study uses a concentration-response (C-R) model with a pooled estimate of the relative risk (RR) values for six health outcomes, including overall mortality, to more precisely estimate the avoided mortality cases from the avoided emissions for both scenarios.

2. METHODOLOGICAL APPROACH

First, a new saturation level for CNG-fueled vehicles is estimated using the autoregressive distributed lag approach, and the vehicle population is calculated using the Gompertz model until 2050. The Gompertz curve is an S-shaped curve that forecasts the expansion of the automotive industry in three stages: a period of slow growth at the beginning (when economic levels are low), a period of boom, and a period of saturation (when vehicle population growth approaches the saturation level). The Gompertz can be explained in large part by the GDP per capita as follows:

$$V_i = e^{\delta e^{\mu(GDP)i}}$$

Based on GDP per capita, this function forecasts the number of vehicles owned per 1000 persons.

The avoided emissions from replacing petrol and diesel-fueled cars with CNG are also computed using ASIF Framework.[2] The avoided emissions by each scenario can be calculated as follows:

$$\Delta E = E_b - E_a$$

Appropriate infrastructure development for nonmotorized vehicles is required but motivating people to use them is a considerable issue. A binary logistic model is used to analyze the willingness to use nonmotorized vehicles. Based on the data collected from a survey of 289 city residents of Dhaka, the effect of various characteristics such as age, gender, occupation, income, and travel modes on the likelihood of willingness to use NMT is examined. The model can be estimated as follows:

$$\ln\left[\frac{P}{1-P}\right] = \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

For both scenarios, excess deaths or illnesses derived from an increase in concentration in terms of the population-attributable fraction can be calculated as follows:

$$ED = PAF * I * F$$

The overall flowchart of the health impact assessment model is given in Figure 1:

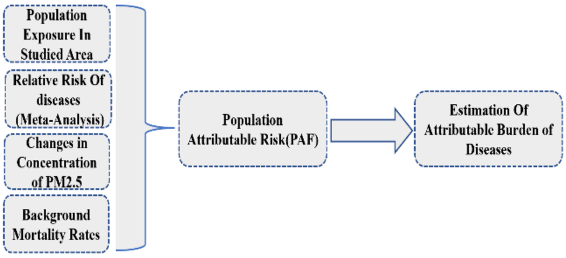

Fig 1. The overall flowchart of the health impact assessment

4. RESULTS AND DISCUSSION

To calculate the baseline scenario or an initial emissions assessment of the transport sector of Dhaka city, data on the total number of vehicles, the share of vehicles by fuel use, utilization rate, annual average distance travel, and fuel efficiency are used. Using the Gompertz equation, vehicle population was calculated until 2050 (Figure 2).
2020 is the baseline year, covering an overview of Dhaka city transport. transport sector is responsible for 9.5 million tons of the city of Dhaka's total GHG emissions. The estimated emissions of SO_2, NOx, $PM_{2.5}$, and CO are 12.15, 68.28, 4.16, and 132.07 kilotons, respectively (Figure 3). The PKM of NMT was calculated based on willingness in Fig 4. This study uses the PKM of nonmotorized vehicles to calculate the avoided $PM_{2.5}$ from motorized vehicles in figure 5 (Buses and cars).

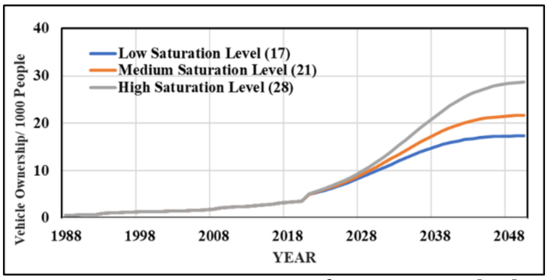

Fig 2.Future projection of CNG-run vehicles

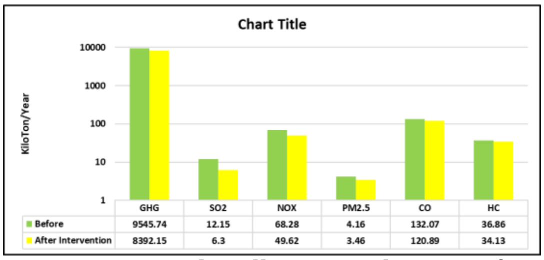

Fig 3. Expected pollutants reduction of CNG vehicles

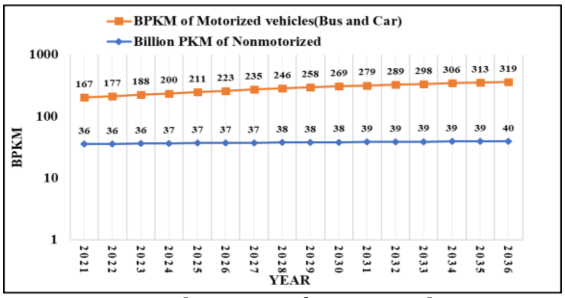

Fig 4. The PKM of NMT until 2036

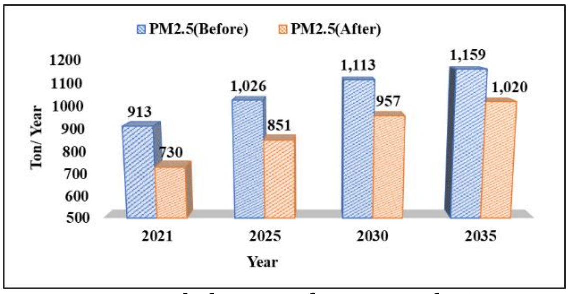

Fig 5. Avoided $PM_{2.5}$ of NMT until 2036

The annual co-benefits of two low-emission scenarios are summarized in Table 1.

Table 1. The annual co-benefit of two scenarios

Co-benefit	CNG scenario	NMT scenario
Avoided $PM_{2.5}$	16%	21%
Avoided all-cause Mortality	5012	6595

It has been demonstrated clearly that the switch to CNG has had a significant positive impact on the air quality of Dhaka residents. This research found that nonmotorized vehicles in Dhaka city benefit larger from keeping the environment pollution free. The expenses of transitioning to CNG need to be estimated through more research. The Bangladesh government has implemented a wide range of strategies to tackle the pollution issue in Dhaka. However, the majority of the policies cost money and take time to implement. By comparing the two low emissions scenarios, it can be concluded that the city of Dhaka will benefit more if nonmotorized vehicle implementation is prioritized.

5. CONCLUSION

In this research, two low emissions scenarios of Dhaka city are considered. The co-benefit assessment of CNG conversion is analyzed. It is found that 12% of GHG emissions are reduced by using CNG fuel-run vehicles. The health benefit is calculated as 5,012 avoided total mortality due to avoided PM2.5 concentration. CNG fuel price is lower than petrol and diesel. 2.42% VKT has increased due to CNG conversion. In the second scenario, the effect of willingness is estimated, and the passenger-kilometer for nonmotorized vehicles is calculated based on willingness. It was estimated at 37.14 kilometers for each person every month. The current nonmotorized vehicles continue to contribute to reducing 21% of PM2.5, preventing 6,595 total deaths from averted PM2.5 concentration.

6. REFERENCES

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