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Revolutionizing Urban Transportation: The Role of Metro Bus Service in Mitigating Carbon Emissions in Islamabad-Rawalpindi Region

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Abstract

Transport sector of any economy is considered as a vital economic factor as almost every individual is highly dependent on transport for having access to their destinations such as educational institutes, offices and other places. Due to increased demand for transportation, congestion problems are also increasing manifolds. This traffic congestion further causes increased atmospheric pollution. In order to control this environmental problem related to road congestion, the capital city of Pakistan; Islamabad with its twin city Rawalpindi launched a metro bus service with an aim to facilitate the commuters of twin cities from traffic blockage and air pollution. The target of the paper is to find out the carbon emissions reduced after the initiation of bus rapid transit in the region. Apart from other benefits associated with Metro Bus Service, one of the major benefits received from Metro Bus Service is that with its launch in cities overall air quality is improved as it has replaced approximately 700 public vehicles from the existing track, which results in the reduction of around 8000 metric tons of carbon emissions from the region.

Keywords: Metro bus service; Mode shift behavior; Carbon emissions; Climate change.

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1. Introduction

Rapid urbanization is leading to a significant influx of rural citizen migrating towards cities for the search of job opportunities as well as improved facilities. Due to significant influx of migration towards urban cities demand for transportation also rises, thus showing a close relation with migration. In order to have access towards workplace and other requirements, every individual is highly dependent on transportation (Deborah and Aligula, 2012). As rate of motorization increases with an increase in urban population, which leads towards adverse effects of ecosystem of urban cities. Due to increased growth rate of urban population, demand for motorization also increases, which then causes congestion in cities (UN-Habitat, 2012). Consequently, congestion causes a significant impact on wastage of time in traffic. Traffic congestion further causes environmental problems, including climate change and air pollution. The growing discharge of greenhouse gases (GHGs), particularly carbon dioxide (CO_2), is a significant problem and is believed to contribute to more severe weather patterns such as heavy rainfall and drought (UN-Habitat, 2012). According to the European Environment Agency (EEA, 2008), approximately 25% of global CO_2 emissions can be attributed to the transportation sector. China and India alone account for about 55% of the global rise in transportation carbon emissions between 2005 and 2030 respectively. As developing countries experience population growth and increased prosperity, this share is expected to increase further (Doll & Balaban, 2013). Substantial reductions in emissions are necessary in order to achieve the targets fixed by the Intergovernmental Panel on Climate Change (IPCC). According to the statement given by IPCC that in order to confine the global warming below 2 degrees Celsius by year 2050, almost 50% cut in green house gas emissions is necessary to limit global warming to below 2 degrees Celsius (IPCC, 2014).

Road congestion, noise pollution, high energy consumption, air pollution, and traffic accidents are among the transportation-related issues that urban centers around the world must contend with (Jain and Khare, 2010). Governments all over the world are struggling to deal with these serious traffic problems. Since the number of vehicles is increasing faster than transportation infrastructure, developing cities in particular face even more severe issues (Santos et al., 2010).

Islamabad, the capital city of Pakistan, is one such city that is going through significant growth as a result of population growth and migration. Many people travel to Islamabad from nearby cities like Rawalpindi, Taxila, and Hasanabdal in search of employment and economic opportunities because it serves as a hub for economic, political, and commercial activities. Since private transportation is the primary means of getting between these cities, the increase in the population has led to a greater reliance on personal vehicles (Asian Development Bank, 2012).

With a population of approximately 4.5 million, Islamabad, Pakistan's capital, is considered to be the third-largest urban conglomeration in the nation (Pakistan Bureau of Statistics, 2015). Islamabad is also home to its twin city Rawalpindi. Over 210,000 vehicles can fit on the three main corridors in these cities, carrying about 525,000 passengers. Currently, private transportation serves as the main means of travel between these cities (Asian Development Bank, 2012). The amount of vehicular activity has significantly increased recently, which has had a negative impact on the urban ecosystem, increasing atmospheric pollution and altering land use patterns. In June 2015, the federal government and the Punjab Metro Bus Authority introduced a bus rapid transit system in the Rawalpindi-Islamabad to address these urgent problems. The metro bus system has a number of benefits, such as a decrease in traffic accidents, time and operational cost savings, and the promotion of a healthier urban environment by reducing traffic and pollution. According to Asian Development Bank (2012), the bus rapid transit system has the potential to replace over 15 million kilometers of travel each year by wagons, cars, and motorcycles, significantly reducing the amount of CO_2 emitted by over 4,000 tons. These pressing problems can be addressed with the implementation of an urban transportation system that is environmentally friendly, such as bus rapid transit, in addition to a change in transportation preferences. The metro bus service has many advantages,

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including lessening traffic jams, reducing accidents, saving passengers' time, lowering air pollution, and conserving fuel (Murty et al., 2006).

2. Literature Review

Due to its ability to help people access jobs, products, and services that satisfy their needs and wants, transportation is essential to human society (Salon, 2012). Although there is a greater demand for public transportation, this is having a negative impact on the urban ecosystem because it is causing traffic congestion and air pollution in the transportation industry. Mass transit systems provide an effective mobility solution that can reduce traffic to address these issues. Notably, Bogotá's TransMilano and Curitiba's BRT service, both of which were introduced in Brazil in 1974 and 2000 respectively, served as models for many Latin American cities to follow. Passengers receive a number of advantages from the implementation of BRT, including less traffic congestion, fewer accidents, time savings, lower air pollution, and fuel savings (Murty et al., 2006).

In a study by Salehi et al (2016), the metro bus system's environmental effects, both good and bad, were assessed in 2016. The findings showed a 6.5liter annual decrease in fuel consumption. In addition, the implementation of BRT in Tehran resulted in the removal of 29,450 taxis from the route and the elimination of about 8,000 tons of various air pollutants, including CO, NO, NOx, and SO_2. The loss of vegetation along the route and the reduced revenue for shop owners as a result of parking restrictions imposed by the BRT were two negative effects, though.

Between 1957 and 2002, the population of cars and two-wheelers increased significantly in Delhi, the Indian city with the highest percentage of motor vehicles, by 60-fold and 200-fold, respectively. However, the introduction of the metro system led to a shift in the preferred mode of transportation from private to the metro, which reduced Delhi's carbon emissions by 23% (Thynell et al. 2010, Badami and Haider (2007), and. Sharma et al.'s latest investigation. (2014) investigated the reductions in carbon emissions brought on by Delhi's introduction of the metro bus system. The study calculated that, between 2006 and 2011, commuters who took the metro rail instead of driving were responsible for replacing an estimated 23,111 and 110,954 vehicles, respectively, based on data on average trip length, occupancy, and kilometers traveled. According to these projections, carbon emissions decreased by up to 7,120 tons within a year, or about 1,882 tons in 2006. Doll and Balaban (2013) evaluated the Delhi metro's environmental benefits in addition, noting that it was the first rail project in history to receive carbon credits through the UNFCCC's Clean Development Mechanism. Between 2007 and 2017, the Delhi Metro Rail Corporation projected a reduction of 41,160 tons of CO_2 equivalent annually, for a total estimated reduction of 411,600 tons of CO_2 equivalent by 2017 (UNFCCC, 2007).

Other metropolis with similar beneficial effects have been seen. Bogota's carbon emissions were reported to have decreased by almost one million tons annually in 2012, while Johannesburg's carbon emissions decreased by 40,000 tons annually after the construction of the metro (Jiice, 2012). In Mexico, carbon emissions were reduced by 27,000 tons (INE, 2006), and Istanbul saw a daily reduction of 167 tons (Alpkokin and Ergun, 2012). Case studies on four BRT systems showed that the advantages outweighed the drawbacks, with positive net present advantages and an internal rate of return that exceeded the opportunity cost of public investment (Carrigan et al., 2014). Phases 1 and 2 of the Delhi metro service, spanning 108 kilometers, were the subject of a 2006 analysis of the costs and advantages. According to the study, accounting for the advantages of Delhi's metro system's role in reducing urban air pollution increased the economic rate of return to 23.9%, which corresponds to an increase in the public's advantages of 1.4%. In addition, Levinson et al. (2013) found that the installation of the metro bus system removed approximately 80,000 vehicles from the route which results in a daily reduction of 623 tons of CO_2 emissions. According to the available research, switching from private vehicles to public transportation, like the metro bus system, could reduce carbon emissions.

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3. Description

To stop the city's serious problems, like increased rates and clogged roads, the Government of Punjab launched an initiative to reduce air pollution with the help of the federal government in Rawalpindi-Islamabad region in June 2015, hence launched bus rapid transit system namely Metro Bus Service. The route of metro bus service is 22.5 kilometers long, beginning in Rawalpindi, with 24 stations. There are ten stations in total in Rawalpindi (8.6km). However, there are 14 stations altogether in the Islamabad region (13.9km). Its daily capacity is 125,000 passengers (Pakistan Metro Bus System, 2016). These BRT buses are kept apart from other vehicles to increase travel speed. They are made to give their passengers a secure and cozy environment. Numerous advantages of using the metro bus include a decrease in traffic accidents, savings in transportation and operating costs will contribute to better urban conditions by cutting back on traffic and pollution. The bus rapid transit system has improved the environment by replacing more than 15 million km of travel by wagons, cars, and motorcycles each year. The more significant reduction in CO_2 discharge will have a positive impact on climate change more than 4,000 tons annually (Asian Development Bank, 2012).

4. Carbon Emission Calculations

For the calculation of carbon emissions that have been reduced by the launch of bus rapid transit in last two years, this study focused to figure out total number of public vans which have been replaced by the launch of Metro Bus Service. Secondly according to propulsion systems of public vans, total amount of carbon emissions has been calculated and then in the end it is compared with the amount of carbon emissions released by Metro Bus Service. After doing so, the difference among these estimates is calculated to find out the amount of carbon emissions declined in the last couple of years after the launch of Metro bus service.

Carbon Emission Reduction

According to the data provided by "Excise and Taxation Department, Islamabad Capital Territory" (2017) a total of 700 public vans are replaced after the implementation of metro bus service in the region. These replaced vans initially traveled at a distance of 25 kilometers daily on routes 1 and 1c, which are now replaced by route designated for Metro bus service. These vans travelled approximately 5 to 6 trips daily on these routes. Emissions from three propulsion systems i.e. petrol, diesel and CNG are calculated and then compared by the CO_2 emissions emitted by bus rapid transit. According to "Ecoscore" (2017) and "Company Car Tax Calculator" (2017) standard calculations for CO_2 emission level from fuel consumption are given below:

- 2392 grams of CO_2 emissions emitted by 1 liter of petrol.
- 2640 grams of CO_2 emissions emitted by 1 liter of diesel.
- 2666 grams of CO_2 emissions emitted by 1 kilogram of CNG.

According to the information given by Company Car Tax Calculator, 2017, obsolete engines might have chance of losing a few percent due to unburnt fuel, but otherwise technology can have little effect on this chemistry.

Table 1: Calculations for Fuel Consumption and CO_2 Emissions

Propulsion System	Consumption /trip/vehicle (liters)	Consumption /700vehicles /day (Liters)	CO2 emissions /liter (Grams)	CO2 emissions /day (Metric Tons)	CO2 emissions /year (Metric Tons)
Petrol	3 Liters	25200 Liters	2392	60.27	18083
Diesel	2.5 Liters	21000 Liters	2640	55.44	16632
CNG	2 Kg	16800 Kg	2666	44.78	13437

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Table 1, shows the consumption of fuel by vehicles having different propulsion systems. For vehicles having petrol propulsion system, for covering 25 kilometers distance by a single vehicle, approximately 3 liters of petrol is consumed. The amount of fuel consumption used for travelling 12 trips per day by 700 vehicles is 25200 liters. Similar to this, if 1 liter of gasoline emits 2392 grams of CO_2, then gasoline-powered vehicles emit about 60.27 metric tons of carbon dioxide per day and 18083 metric tons of CO_2 per year. A single vehicle needs about 2.5 liters of diesel to travel 25 kilometers if it has a diesel propulsion system. Total fuel consumption for 12 daily trips made by 700 vehicles is 21000 liters. If 1 liter of diesel emits 2640 grams of CO_2, then diesel-powered vehicles emit 55.44 metric tons of carbon per day and 16632 metric tons of carbon annually. A single vehicle needs 2 kg of CNG to travel 25 kilometers. The total amount of CNG used for the 12 daily trips made by 700 vehicles is 16800 kg. When CNG is used in vehicles, 44.78 metric tons per day or 13437 metric tons of carbon dioxide are released annually, if 2666 grams of CO_2 are released from 1 kg of CNG.

5. Fuel Consumption of Metro Bus

On the other hand, 60 buses operate along this route, covering a total of 16906 kilometers while using 9798 liters of diesel each day. If one-liter diesel emits approximately 2640 grams of carbon emissions, then 9798 liters of diesel emits a total of 25,866,720 grams of carbon emissions.

300*25,866,720 = 7,760,016,000 grams of CO_2 7760 metric tons of CO_2/day /anum emitted from metro buses per year. It means that 7760 metric tons of carbon emissions are emitted per day per anum by metro buses.

Table 2: Calculation for Reduction in CO_2 Emissions

Propulsion System	CO2 Reductions (Metric tons/anum)
Petrol	10323.5
Diesel	8872
CNG	5677

Table 2 makes it clear that by taking the place of public transportation on the route, the metro bus system has significantly reduced the amount of carbon emissions, leading to improved air quality. The table makes it clear that approximately 10323.05 metric tons of carbon emissions would be reduced if the old vehicles had been powered by gasoline. Likewise, 8872 metric tons of carbon emissions would be reduced if the replaced vehicles operate on diesel. While 5677 metric tons of carbon emissions are lowered annually by CNG vehicles. In summary, it is clear that the metro bus system has helped in maintaining the area's ambient air quality**.**

6. Conclusion

According to the study, there are now fewer than 700 public vehicles on the metro bus route. So far, the city has reportedly reduced its carbon emissions by about 800 metric tons. In previous studies, it was found that Bogota reduces its carbon emissions by almost 1 million tons annually (Turner et al. 2012), approximately 167 tons of carbon emissions are decreased each day in Istanbul (Alpkokin and Ergun, 2012). Levinson and others (2013) discovered that the introduction of the metro bus resulted in the removal of 80,000 vehicles from the road and a corresponding 623 tons of CO_2 emissions.

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