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Consideration of access and egress trips in carbon footprint estimation of public transport trips: case study of Delhi

Kirti Bhandari [a, *], Mukti Advani [a], Purnima Parida [a], S. Gangopadhyay [b]

[a] Transport Planning Division, India
[b] Director, CSIR-Central Road Research Institute, New Delhi, India

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ABSTRACT

Urban configuration and urban transport system have an enormous impact on the travelling pattern of people. Travel can be characterized by trip frequency, travel distance, modal choice etc. With, the rapidly growing economies and population, there is an increasing trend of urban sprawl and auto-mobilization. This has a direct effect on the level of transport demand, travel patterns and its impact on the environment. Present study focuses on trip profile of the commuters by available modes to estimate the carbon footprints for different mode-combinational trips (trip profile including access, egress and main line haul mode) in public transport systems existing in Delhi, the capital city of India. The aim of the study is to include access and egress parts of the public transport trips (i.e. bus and metro) in carbon footprint estimation along with the main line haul trip which is lacking from traditional methods of carbon footprint estimations. This methodology consists of estimating the direct CO_2 emissions for different mode combination trips including the access ad egress trips with the main haul trip which is by bus or metro and comparing them under different scenarios. Carbon footprints of urban commuting provide insights into the potential impact of different policies. Questions such as where to apply certain policies (both in terms of mode and geographic area) to gain the largest reductions can be answered using such footprints.

1. Introduction

Rapid and expanded urbanization occurring around the world involves an increased number of trips in urban areas. Cities have traditionally responded to growth in mobility by expanding the transport supply, by building new highways and/or transit lines. In the developed world, that has mainly meant building more roads to accommodate an ever-growing number of vehicles, thereby creating new urban structures, with the reliance on the automobile being the most important discriminatory factor (Rodrigue et al., 2006; Pucher et al., 2007). Cities are locations having a high level of accumulation and concentration of economic activities and complex spatial structures that are supported by transport systems. The most important problems are often related to urban areas, when transportation systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility. Urban productivity is highly dependent on the efficiency of its transport system to move labour, consumers and freight between multiple origins and destinations (Rodrigue et al., 2006).

As the demand for transport is increasing, the need for sustainable modes becomes more evident. The need for more plentiful and efficient public transport becomes essential to reduce traffic congestion which is mainly caused by private transportation. Public transport systems can move large numbers of people, thus collectively using scarce resources such as land and fuel more efficiently, resulting in lower overall environmental costs. Public transport modes are regarded as city-friendly as they provide safe efficiency. The most important benefit of public transportation is that it reduces the need and desire for private vehicle ownership to some extent and thus can massively reduce the amount of motorized travel (Barter and Raad, 2000).

Successful public transport systems that compete with private modes, such as the car and the motorcycle, could retain customers from all social classes (not just the poor) and be used for a wide range of urban trips at all times of the day (not just for trips to work

* Corresponding author. CSIR-Central Road Research Institute, Transport Planning Division, Mathura Road, New Delhi 110025, India. Tel.: +91 9971331223.
E-mail addresses: kirti.bhandari7@gmail.com (K. Bhandari), mukti7@gmail.com (M. Advani), punam31@gmail.com (P. Parida), sgp.crri@nic.in (S. Gangopadhyay).

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during peak hours). For this to be achieved there is a need for a well-planned public transport system which is affordable and is attractive to all groups of people.

Despite the advantages of using public transport, there is an increasing trend in the use of private cars and motorcycles in both the developed and the developing world due to poor public transit services. The private vehicle is winning the mode share in many nations. As income rises in developing nations, private vehicles are gaining usage while public transport ridership is almost universally declining (Wright and Fultan, 2005).

1.1. Significance of access and egress in public transport trips

Access and egress are the weakest links in a public transport chain and determine the availability and convenience of public transport. Initiatives aimed at improving access and egress hold potential to significantly reduce public transport trip time and are inexpensive options compared to the expensive infrastructure and vehicle enhancement alternatives frequently considered.

The influence of the access and egress on the availability and catchment area of public transport has received much attention. An increase in distance to a transfer location (i.e. bus stop or train station) significantly reduces the propensity to use public transport (Keijer and Rietveld, 2000; Loutzenheiser, 1997; O'Sullivan and Morrall, 1996; Parsons Brinckerhoff Quade and Douglas et al., 1996; White, 1995). This distance decay is very much a function of the different access and egress modes with certain modes being more sensitive to distance. The action radius (spatially delimited interaction range) of walking, for example, is significantly smaller than that of the bicycle and the car. Walking (and slow modes in general) involves a certain amount of physical effort not present in other, motorised access and egress.

Since access and egress modes determine the catchment of public transport stops and the intensity of use within catchments, many researchers have considered how land use and transport policies can be used to increase the catchment, that is, the physical size of the catchment or the intensity of public transport use within the catchment. Density, diversity, design, layout, etc. are frequently considered as spatial policy instruments to increase and/or intensify catchments (Loutzenheiser, 1997). Findings of the relationship between access (and egress) mode choice and land-use and individual characteristics, however, are mixed. Some research has shown that the share of walking increases with increasing density, diversity and design (Loutzenheiser, 1997; Parsons Brinckerhoff Quade & Douglas et al., 1996) while other research has found the share of walking to be primarily a function of individual characteristics, with land-use characteristics being of secondary nature (Frank and Pivo, 1994). All research, however, confirms that distance to/from transfer locations is the most important factor in access/egress mode choice and probably the ultimate disincentive in the use of public transport.

Also, Van den Enden and Lohuizen (1983a,b, p. 598) concluded that, "**when the length of the journey is short, the influence of access distance is large**". They found that commuters whose train travel time (main mode) is relatively short tend to go by car sooner than commuters whose train travel time is relatively long (Van den Enden and Van Lohuizen, 1983a,b). Again, this highlights the potential importance of the relative access and egress time as a factor in mode choice.

2. Objectives

The aim of the study is to assess urban mass transport systems in relation to travel mode choice for commuting trips. Using carbon footprint concept to evaluate sustainability, it is possible to represent and communicate effectively the issues of environmental impact and sustainability. The main objective of the study was to focus on estimating the carbon footprint due to commuting focussing on the public transport modes. The study also estimated the environmental impact of different travel options available for commuters. More importantly, the study evaluated the impact of "zero" carbon modes such as walking, cycling and rickshaws, on the carbon footprint of commuting. The study focuses on the inclusion of access and egress parts of the public transport trips (i.e. bus and metro) in carbon footprint estimation and their comparison.

3. Study area

Delhi being the capital city is the centre of socioeconomic, cultural and political activities of the country. The city also acts as a major centre of trade and commerce and is the nodal point for five national highways and intercity rail corridors, carrying large volumes of heterogeneous passengers and goods traffic. The national highways and other major road network carry intra-city and intercity traffic traversing to and from the different parts of the country.

Delhi has a well-developed transport network system, based on a ring and radial pattern, consisting of a large fleet of Delhi Transport Corporation (DTC) buses running on Compressed Natural Gas (CNG), and a suburban rail system which is a Mass Rapid Transit System (MRTS) known as the Delhi Metro. The majority share of the travel needs of Delhi commuters is met by road-based transport systems.

There has been a major improvement in transport infrastructure in recent years in terms of flyovers, road-widening, development of new roads, and development of metro rail corridors along major travel routes in the city. Due to a continuous increase in population, employment opportunities and number of vehicles, there has been a constant increase in demand over the years; and the infrastructure has not grown in adequate proportions, making the existing network system function beyond its capacity. This has led to serious traffic problems of congestion, delays, safety, pollution and safety management.

Delhi is the converging point for five rail lines and five national highways. The growth of Delhi over the years has been on a ring and radial pattern, with reliance on a road-based public transport system. The draft master plan 2021 emphasizes the need for multimodal transport system, with an optimal mix of rail and road based systems. Integrated multimodal public transport has been proposed for the city, which includes: metro (6 corridors), at grade HCBS (26 corridors), elevated LRT (6 corridors), elevated monorail (3 corridors), and integrated rail-cum-bus transit (IRBT) (2 corridors) (CDP, 2006 pp. 11–21, 22).

The development envisaged by the master plans was poly-nodal with a hierarchy of commercial centres located on either ring or the radial roads. The proposed metro network is thought to have a sizeable impact on the urban form and the related commuting patterns. The concept of the master plan 2021 is based on a poly-nodal, polycentric distribution of work centres, largely based on road transport nodes. This essentially implies that development should take place according to new corridors of mass movement, especially along major transport corridors and the mass rapid transit system.

4. Research framework

The framework followed in the study is shown in Fig. 1. As a first step, data collection through passenger interview survey followed by compilation and preliminary analysis is carried out. Further analysis deals with the estimation of carbon footprint of commuting during each trip in the study area, i.e. Delhi using the