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Freight Distribution through Urban Rail System- Case Study–Delhi

Monika Singh[1] and Debraj Chakraborty[2]

[1,2]Faculty of Architecture, Manipal University
E-[1]monika548tp@spa.ac.in, [2]debrajchakraborty99@gmail.com

Abstract—*The movement of goods within urban areas is vital and has an important role to play in the economic development of the city. With the growing economy the cities in India are focusing on building their infrastructure development plans to handle largely the passenger movement whereas the freight sector is in negligence and continues to account for negative externalities in terms of emission, congestion, safety and energy costs. Moreover very insignificant attention is paid to evolve a sustainable urban freight distribution policy in cities which can minimize various externalities. The present study is an attempt to explore the possibility of using urban rail system in terms of metro and ring rail as a potential freight distribution mode to achieve a sustainable urban freight distribution environment in context of Delhi.*

1. INTRODUCTION

The movement of goods within urban areas is vital since cities are the center of economic and social life. Freight movement in the cities often puts considerable strain on urban transport infrastructure and imposes high social costs. Cities are now facing global competition for investment and trade when an efficient transport system is necessary for sustained economic prosperity. The explicit consideration of urban goods movement has the potential to contribute towards achieving the goals of urban transport. The objectives of city planning, in particular, and city transport system planning, in particular, is to enable goods movement at desired levels of efficiency of goods movement. Goods movement is increasingly becoming recognized as an integral component of urban transport planning. The freight movement in cities of India varies by size and function of the cities. While macro level freight traffic data base is generated as part of comprehensive transport plan preparation exercise undertaken from time to time the freight logistics aspects related to supply chain linkages, storage, handling, distribution aspects including the modes used etc. is not given enough importance. The sector is also faced with a number of challenges such as congestion, parking for deliveries and reverse logistics. Due to the lack of comprehensive understanding among decision makers and operators the image of freight and supply chain sector has taken a severe dent. Our cities are basically designed only considering the passenger movement and neglecting the major part of the traffic that is goods movement and facilities related to it like truck terminals, warehousing facility, and amenities for drivers and crew and important aspect that is supply chain [6].

There are various practices and strategies that were adopted in many Indian cities to cope with the issues related to the freight logistic management, like prohibiting truck entry into the city in day time, restriction on movement of trucks older than 15 years, levying 'Green Tax' on goods vehicle varying with their payload. However there are lots of issues which needs to addressed so as to make the freight and logistic sector works efficiently-

i. Lack of support facilities like storage and warehouse, inland container depots (ICDs), truck terminal, integrated freight complex (IFC) etc. for freight and logistics system makes them to create their own habitat which doesn't comply with the city structure and hence haphazard development is done and causing chaos and congestion.
ii. Lack of comprehensive planning as well as limited or no provision for logistic related facility, private players or truck operators started developing warehouse and storage facility at city periphery, leading to unplanned and sprawled development of the city.
iii. Negligence towards rail based freight transportation.

Some of the sustainable strategies which were adopted in various European nations to lower down the congestion and pollution level in the respective cities include Low Emission Zones (LEZ), Combined Use Lanes, Preferential zoning , Unattended delivery systems and Reverse Logistics, Freight Villages, Low Emission vehicles, environment friendly modes (through existing Rail or tram system), alternative fuels etc. Amongst all these measures use of low emissions vehicles for freight distribution in urban areas has immense potential to result in sustainable freight distribution patterns in urban areas.

1.1. Research Need

Current urban freight distribution in Delhi is road based generating negative externalities like environmental impact, traffic congestion, accidents and to evolve alternatives to reduce all these externalities and to achieve this rail can be used as alternate mode for urban freight distribution as there is spare capacity in both the metro and ring rail EMUs. Also there is no reported research work in India to assess the importance of rail as potential mode for urban freight distribution.

1.2 Objective

i. To review the existing trends and practices of urban freight in Indian cities and identify issues.
ii. To review global best practices or urban rail as a potential mode for freight distribution.
iii. To assess the existing logistic landscape along urban rail network in case study- Delhi.
iv. To assess the characteristics of present freight generation establishment and distribution centers.
v. To evolve and evaluate 'alternate scenarios' of urban freight deliveries by rail system as a sustainable urban freight delivery process.
vi. To recommend proposals for urban freight distribution through rail system.

2. LITERATURE REVIEW

The ability to transport goods safely, quickly and cost effectively is one of the foundations of globalization and economic growth and is based on an efficient freight transport system. Rail can achieve up to 50% of reduction in energy consumption per tonne - km compared to road based freight transport systems [14]. Moreover, the railway also allows the major axis weights and higher capacity of cargo volume for lighter weight products. However, the railroad failed to capitalize on its advantages in order to be used worldwide for urban distribution of goods.

The four case studies were reviewed to understand the role of urban rail for freight distribution in urban areas. These included CityCargo in Amsterdam, Monoprix in Paris, Reverse Logistics in Zurich and CarGo-Tram in Dresden. All these cities are utilizing their existing rail network for the efficient freight delivery within the city like transportation of automobile parts, small retail products, electronic waste and bulk refuse. The network length varies from 5 km to 30 km whereas maximum tonnage handled per year ranges from 1000 to 3, 00,000 tonnes per annum. It is observed that urban rail for freight distribution has many advantages such as up to three times reduction in CO_2 emission and congestion on road, reduction in 700,000 km of truck km and also 70,000 liters of fuel savings besides reduction in externalities in the form of congestion, noise pollution and emissions [2, 5, 8, 9].

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The main weakness identified in urban rail as freight distribution carrier in cities are poor door to door capacity; inflexibility; competition with passenger services line capacity; the perception of rail infrastructure and high costs related system [11]. It is important that railway disadvantages are overcome and to enable urban freight distribution through rail system. Urban rail transit systems (tram, metro and light rail) appear to be possible solution for freight distribution in urban areas.

3. FREIGHT PROFILE OF DELHI

Delhi being the capital city, it is the center of many economic activities varying in between secondary and tertiary activities. The trade and commerce has played a very important role in determining the economic growth of the city by contributing significant tax revenues and providing employment opportunities to the large section of the society. Delhi being the biggest trading center as well as the consumption level of the city has attained the characteristics and status of a major distribution center due to geographical location, historical characteristics and availability of infrastructural facilities etc.

The total originating tonnage was 58,114 tonnes and 90,488 tonnes for the year 1993 and 1996 respectively with 15.9% annual average growth rate (AAGR) whereas, destined tonnage accounts for 76,108 tonnes and 1,92,238 tonnes for the year 1993 and 1996 respectively with 11.2% Annual Average Growth Rate (AAGR) [13]. For estimating intra city freight traffic demand there are no estimates available for Delhi. Hence using the CRRI study "Estimation of Short Haul and Suburban Freight Traffic, 1998" equations shown below in Table 1 the estimated intra city freight in Delhi has been estimated.

Table 1. CRRI Study Equations [1]

Inter City Inbound	Inter City Outbound	Intra-City Flow
IIV = 33.1(P)0.63	IOV = -333.4 + 1.3613(P)	IV = 1.32(P)1.08
IIT = 91.2(P)0.75	IOT = -2683 + 9.01(P)	IT = 1.62(P)1.08

Where,

IIV: Intercity Inbound Vehicular Trips
IIT: Intercity Inbound Tonnage
IOV: Intercity Outbound Vehicular Trips
IOT: Intercity Outbound Tonnage
IV: Intercity Vehicular Trips
IT: Intercity Tonnage
P: Population

Table 2 shows the estimated freight traffic in terms of destined, originating and intra city, both in terms of vehicles and tonnage. For validation purposes the SPA 1993 and 1996 study observed data of originating and destined freight traffic were adopted to estimate the intra city freight traffic for different years. From the above Table 2, the total tonnage moving within the city (intra city) in 2016 is estimated to be 67,120 tonnes and 54,690 freight vehicles respectively.

Table 2. CRRI Study Validation with SPA Study [12]

Year	Pop. in lakh	Destined		Originating		Intra City	
		Veh	Ton	Veh	Ton	Veh	Ton
1991	94.2	10	87	125	82	26	32
1996	114	12	**100**	152	**99**	32	39
2001	138	13	116	184	122	39	48
2011	168	15	134	225	148	48	59
2016	189	16	147	253	167	55	**67**
CAGR (%)	3	2	2	3	3	3	3

Vehicles and Tonnage figures are in thousands.

Values for the year 2016 is estimated for the purpose of this study.

4. DATA BASE

Data has been collected from both the secondary sources and primary surveys as well as reconnaissance survey too. Data requirement is in the form of GIS map of Delhi for land use and road network characteristics, India Post & Courier's demand and supply, Ring Rail and Metro spare capacity and truck operator opinion related to introduction of new system. From the secondary sources, data related to Master Plan of Delhi – 2021, population trends from census, annual reports from India Post for the assessment of postal demand in the horizon year 2026 and urban rail system characteristics i.e., their ridership data over the day, yearly ridership, time table and technical aspects related to coach design was collected.

As part of the primary surveys establishment survey was done with 4% sample of India Post and 9.5% sample of Courier agencies. Besides 80 freight operators were collected related to opinion of freight operators all along the urban rail corridor including LCVs or tempos owners. Various operators were surveyed in locations like Sanjay Gandhi Truck Terminal, Punjabi Bagh Truck Terminal, Azadpur Sabji Mandi, Okhla Mandi, Kirti Nagar Timber Market etc. Handling variety of commodities such as FMCG, electronics, fruits and vegetables, automobile parts, cement etc.

5. ESTABLISHMENT AND OPERATOR PROFILE

From the secondary data analysis it was observed that 43% of DPOs (delivery post offices) were The average tonnage generated per establishment of both the postal and courier is 143 kg and 22 kg respectively with average weight of each article or consignment is estimated to be 300 grams, whereas from the operator survey 65% are willing to shift which within 1.5 km to 2 km catchment of the urban rail corridor to the new system to be introduced that freight delivery through urban rail system.

6. COMMODITY CHARACTERISTICS

In Delhi, as per the Annual Report of India Post 2015, there are total 493 DPO, where each DPO serves 38,235 persons on average over a catchment area of 3 sq.km while for 400 estimated courier agencies the average population served by each agency is 47,125 persons and the area served is 3.71 sq.km. From the GIS mapping the number of DPOs and courier agencies within one km catchment of urban rail corridor are 213 and 142 respectively. From the primary survey and annual report it is observed that the average weight of each article/ commodity is found out to be 300 grams. The estimated total tonnage from India Post of 36.7 tonnes and 2.9 tonnes from Courier Agencies totaling to potential 40 tonnes of traffic which lies within the catchment of the urban rail network [7].

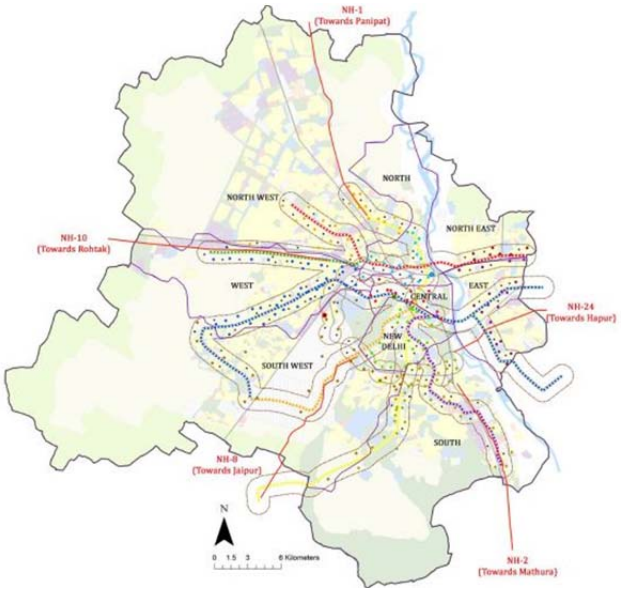

Fig. 1: Postal and Courier establishment within 1km catchment of Urban Rail System [12]

7. SPARE CAPACITY ASSESSMENT ON URBAN RAIL SYSTEM IN DELHI

For this study two urban rail system have been considered to transport the case commodity, namely Delhi Metro and Ring Rail as these two systems covers almost 87% (GIS mapping of land use and rail system with one kilometer buffer) of Delhi's population in ring and radial form. From the ridership trends and number of coaches being operated over the due course of time, time slots were identified in which freight operation can be carried out without interfering with the passenger operation. For the Metro on all the five lines, morning 5 am to

6 am and in night 11pm to 12 am is identified as the time for potential use for freight traffic whereas in case of Ring Railway while the EMUs running for passenger, their vendors coach will be utilized for the freight delivery during the operational hours [4].

The availability of spare capacity in Metro and Ring Railway has been studied from the trend of ridership data. Hence the actual capacity available in tonnes is calculated by considering the following assumptions:

i. Per person weight = 75 kg
(Average person's weight = 68 kg and average baggage weight = 7 kg)
ii. Capacity of each Car = 375 persons
iii. For spare capacity calculation first and last trips were considered to avoid interference in passenger service

Keeping in view the above facts the spare capacity available in Metro Rail is estimated to be 7,332 tonnes and in Ring Rail it is estimated to be 230 tonnes (capacity of one Vendor's Coach = 23 tonnes; number of trains available = 10). Hence, the total spare capacity available in both the rail systems is estimated to be 7,562 tonnes.

8. ALTERNATE SCENARIOS OF FREIGHT DISTRIBUTION BY RAIL SYSTEM

To assess the feasibility of the introduction of new system for freight distribution four alternate scenarios along with BAU scenario. Integration of new modes will be in terms of Metro, Ring Railway and LCVs or Battery operated vehicles for the transfer of goods, whereas, there is complete change in supply chain in Scenario 5 by shifting of depots near to the AMPC and RMS services. The scenarios are as under:

I. *Business As Usual (BAU)*: Postal goods from AMPC and RMS to four depots through road based transport system then from Depot to DPOs again through road transport, from DPOs to neighborhood post offices through NMTs.
II. *Scenario I*: Improvement in first leg of the journey that is from Automated Mail Processing Center (AMPC) and Rail Mail Service (RMS) to depots through urban rail system rest the system will be as same as of BAU.
III. *Scenario II*: Improvement in Second leg of the supply chain that is from depot to DPOs.
IV. *Scenario III*: Improvement in both the legs of the supply chain that is transfer of postal and courier goods through urban rail within the catchment zone of one km.
V. *Scenario IV*: Change in supply change by shifting of depots near to the AMPC and RMS so as to eliminate the first leg and multiple handling in between different mode type.

The main findings emerging from the scenario analysis are as under:

i. Carbon credits can be earned by Metro and Northern Railway as it has following Carbon Emission Reduction –

Table 3. Carbon Emission Reduction [12]

Scenarios	2016		2021		2026	
BAU	2571	%	3125	%	3605	%
I	-145	5.6	-1131	36	-2229	62
II	556	21.6	759	24	904	25
III	411	16	-372	12	-1325	36.7
IV	387	15	436	14	3527	97.8

ii. Reduction in total time taken in handling the commodity.

Table 4. Evaluation of Time taken in Commodity Handling [12]

Scenarios	2016	2021	2026
BAU	319	406	448
I	280	274	254
II	282	258	235
III	258	234	210
IV	94	81	62

The reduction in time in the base year 2016 is 29.4% with comparison to Scenario IV, for the same scenario in year 2021 reduction in total handling time is observed to be 20% and for the second horizon year 2026 it is estimated to be 14%.

iii. Reduction in fuel consumption as the total kilometers travelled reduces.

Table 5. Evaluation of Time taken in Commodity Handling [12]

Scenarios	2016	2021	2026
BAU	2074	2614	3081
I	1686	2249	2737
II	1395	1687	1976
III	1007	1323	1632
IV	2521	3064	287

The fuel consumption in comparison between BAU and Scenario IV is observed for base year 2016 has been increased by 21.5% due to multiple intermediate handling but in long run this results into decline of fuel usage it was estimated to be 9% of fuel consumption as what it will be for BAU scenario.

9. SUMMING UP

From this study it can be concluded that in the present state-of-the art city planning and practice in India there is very little importance attached to understanding the characteristics, problems and potentials of goods movement to and from and within urban areas. Urban goods logistics in India cannot be overlooked now and need special focus in all city planning initiatives.

From the literature review it is observed that there is a need to explore the possibilities of urban rail system for freight distribution in urban areas. In the present case paper the case commodities of posts and courier parcels are increasing at an average annual growth rate of 5 per cent. It is observed that the average weight of each case article/ commodity is estimated to be 300 grams. About 40 tonnes of potential post and parcels cargo lies in the vicinity of existing urban rail network in Delhi and has the potential to be distributed by rail system. The spare capacity available on urban rail system is estimated to be 7,562 tonnes with 7,332 tonnes in Metro system and 230 tonnes in Ring Rail (EMUs) respectively indicating a surplus capacity for case commodities distribution.

Alternate scenarios of distribution of case commodities through rail system were developed with varying distribution legs in supply chain networks to assess the usefulness of using rail system over the existing road system based distribution practice with the reduced emission, handling time and fuel consumption. It was observed that there is a potential reduction in carbon emissions by 97.8% by 2026 compared by BAU scenario. In addition there shall be substantial reduction in handling time as well as fuel consumption.

The study recommends that an action plan needs to be prepared for India Posts and Courier Agencies, in terms of shifting of mode for transfer of postal and courier goods as per the postulates in scenario IV. Further there is a need to provide for an area of 1450 m^2 near to RMS and 9800 m^2 near to AMPC for shifting of Depots at Automated Mail Processing Centre and Rail Mail Service respectively. Thirty one stations have been identified as collection and distribution hub for last mile delivery to DPOs. Coding system for distribution of posts and courier from AMPC and RMS for last mile delivery without any intermediate sorting needs also to be developed. Lastly station designs should be in such a way that direct loading and unloading of goods can be done from the train to the delivery vehicles.

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