

IDENTIFYING THE FACTORS INHIBITING RESEARCH ON URBAN FREIGHT TRANSPORT IN DEVELOPING COUNTRIES: REVIEW OF STUDIES IN INDIA

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Abstract: Most of the cities in developing countries are found to have non-uniform distribution of urban space, complex land use patterns, mixed traffic conditions, extensive use of non-motorized vehicles and lack of traffic discipline. In comparison to the developed countries, it is more complicated to manage urban freight transport in developing countries due to the lack of sufficient infrastructure, wide socio-economic gaps between urban and non-urban areas and haphazard peripheral developments. Therefore the methods and strategies used to manage urban freight transport in developed countries cannot be directly used for cities in developing countries. It is necessary to devise distinctive solutions to improve the efficiency of urban freight transport in these cities, which may otherwise, inhibit the economic growth of these cities as well as hamper the overall momentum of country's GDP growth gathered over decades. In recent years some studies focussing on urban freight transport are carried out in India, China and Brazil. This paper reviews urban freight studies carried out for Indian cities. India, world's second most populous country to China, has 39 cities with a million plus population. Most of its cities are facing problems like congestion and air quality degradation due to inefficient freight movement practices. Review of urban freight studies is carried out based on different parameters influencing efficiency of freight movement. Various challenges and limitations faced by the researchers and administrators are discussed. Based on the review results, suggestions and future scope for research in different aspects of urban freight are presented in the paper.

1 Introduction

Cities around the world rely on frequent and timely deliveries of goods and services to its residents, commercial and industrial units [1]. Practitioners and policy makers around the world have realized and acknowledged that goods transportation in cities have become a critical component in the urban transportation systems and therefore research in this area has also been intensified in the recent years. Unlike passenger transport, freight movement systems are very complex in nature, as there are several agents involved in the decision making at every stage [2]. Urban freight is studied quite extensively in the developed countries of Europe and the USA as compared to other parts of the world. In India too, urban freight studies is gradually gathering pace, yet it is at a very nascent stage. The studies carried out in developed countries cannot be directly implemented in India with respect to the research methods used in these studies because of a range of cultural, lifestyle and physical difference among them. Most of the Indian cities are characterized by high population densities, complex land use patterns, short trip length, and a high share of pedestrians and non-motorized vehicles (NMV) in the overall traffic. The transport and land-use patterns of cities in India are highly influenced by socio-economic and

cultural complexities that makes it difficult to analyze their characteristics using the same indices as used for cities in highly motorized countries like the U.S or member nations of EU. In absence of critical analysis of research gap and eye opening research in this area, many researchers are avoiding to pursue research in the field of urban freight due to data scarcity, blind spots in problem statement, complexity of problem due to huge variety of goods and its handling methods, conflicting interest of various stakeholders involved, business secrets, tax policies and other such factors making urban freight transport (UFT) a less preferred area of research.

In the year 2013, India got categorized as a newly industrialized economy from a developing country [3]. A newly industrialized economy is a country whose economic development is between developing and highly developed economies. With 1.36 billion people, India's overall population is second highest in the world after China. India has 39 cities having population of more than a million. Of these cities, there are two having population in excess of 10 million - Mumbai and Delhi. There are 388 cities that have populations between 100 thousand and a million and also it has 2,483 cities with populations between 10 thousand and 100 thousand [4]. In general almost every city in India is facing problems due to its

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inefficient goods handling methods. In India, UFT is highly neglected in policy framing or city management [5]. Literature is available only for a few studies carried out in recent times, as some of the studies carried out by certain industry are only for internal use and hence not shared or published outside. The paper presents a review of urban freight studies carried out for different cities of India to analyze the factors inhibiting or restricting participation from research community as compared to passenger transport. The parameters used for conducting this review exercise have been derived from the various challenges and limitation faced by the researchers who have made some research progress in this area. It also intends to suggest practical recommendations that could facilitate urban freight studies in Indian cities for making UFT systems more sustainable.

1.1 Objectives of the study

Present scenario for overall environment for cities in India is not very encouraging. Due to very high of overall population, rapid urbanization, faster industrialization, and increased motorization of transport facilities; air and noise pollution is rapidly increasing in India [6]. In research studies as well as policy management, road traffic and their impact on the liveability index of Indian cities have received growing attention in recent years, much of this attention is directed to passenger traffic [7]. Despite the fact that UFT is having a very significant impact on the overall liveability of the cities, it has received little attention. The aim of this study is to document research work carried out in this field to know the state of the art practices and improvement measures adopted across the country. In that sense, this study attempts to determine changes needed in policies and practices at develop efficient and sustainable UFT systems for the cities in India. The purpose of the study can be classified into three parts:

- To review the existing studies carried out by various researchers and transport planning professional in different cities of the country.
- To identify the gaps and voids in the systems that limits the role and contribution of research community in improving the current state of practice.
- To provide conclusive steps and practical recommendations for making the UFT systems in the country more sustainable.

The study is geographically restricted to India alone; however it is equally useful neighboring countries like Sri Lanka, Bangladesh and Pakistan where the traffic behaviour is similar in nature. Only documented literature in the form of research articles, conference papers and study reports by government and non-government organizations are considered for the review. Studies of urban freight movement only using roads as the mode of transport is considered in the study, other UFT modes like

urban rail or trams and inland water transport are not considered.

1.2 Search Methodology

Secondary sources in the form articles in scientific journals, articles in press, book chapters, doctoral and masters dissertations and refereed proceedings are used in this review. To find relevant articles popular online databases from - Science Direct, Scopus, Web of Science and Google Scholar were used; keywords like urban freight, freight transport, city logistics, and goods movement were selected for search in title and abstract of the papers for filtering in first stage. Total of 1898 search results were obtained for the time period of 2000-2019 as a result of total studies carried out in the world. During the online search 24 reviews articles in peer-reviewed journal were found, specifically focusing on modelling techniques [8,9], bibliometric analysis [10], urban consolidation and distribution centers [11-13], survey methods [14], sustainability of urban freight [15,16], use of best practices and innovative technologies for freight handling [17-19] and logistics sprawl [20]. The search was further filtered for studies carried out in India. Only a handful of research publications were available on urban freight transportation in developing economies in reputed refereed journal. Further, articles presented at conferences, proceedings and archives of transportation background conferences wherein participation from Indian researchers is found; Transportation Research Board (TRB) Conference, World Conference on Transport Research (WCTR), Institute of City Logistics Conference, Conference of the Transport Research Group of India (CTRG), Urban Mobility India (UMI), Conferences and Eastern Asia Society for Transport Studies (EASTS) and other internationally reputed conferences were searched. Furthermore, studies carried under government projects by academic institutions or other independent consultant were searched from various government reports and other published reports. The review framework used in this paper is an adaption of the urban freight domain analysis suggested by Odgen and Crainic *et al.* [21,22]. Finally a total of 32 total articles were considered selected for reviewing the scenario of urban freight transport in India which is presented in this article.

2 Review process

An urban freight transport system is made up of numerous activities and stakeholders that results in formation of a complex subject to study, in order to understand these issues with simplicity a systematic review of each paper was carried out on the six aspects of urban freight transportation, which are discussed in this section.

2.1 Number of commodity/ services (C/S)

The overall impact of urban freight on city traffic can be estimated when all the freight trips attracted and

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produced are taken in to account. However, in cases where a single industry has very dominant presence in the city and its impact on the overall freight traffic is very high, studies restricted to only such industry can also prove to be very effective. However more such studies needs to carried out focusing on commodities of domestic need like industrial freight needs, FMCG goods, bakery and dairy products.

2.2 Size of study area

The geographical dimension or size of the area chosen for study varied largely in the current study. Some studies were carried out on very small study area like a single main market area (road stretch of 1.5 km); while some other studies included the entire city as well as the surrounding metropolitan areas in the study. Comparison of different cities for a particular parameter is also a form of study attempted by many researchers around the world. Study area is a very important factor determining the application of the study in policy making and hence included in the study.

2.3 Stakeholders

Stakeholders are people who take decisions for the goods movement. They are divided into five categories

based on their attributes, behaviour and roles in the UFT process [23-25]. Details of these categories are as under:

- Administrator; which includes government bodies at the city, state and country level.
- Supplier; who produces and/or supplies various commodities or services to the study area.
- Carrier; who distributes the goods and services from suppliers to receivers outside or within the study area.
- Receiver; who receives various goods or service within the study area and uses or redistributes them.
- Residents; who are the end users of the various goods and services that are available in the urban area.

2.4 Study Objectives

Based on the stakeholder and study area chosen for the analysis, objectives may vary. As such the overall objective for any urban freight study is to reduce the social cost of city logistics [21]. However for the present review objectives are further divided into sub-categories like reducing cost, improving efficiency, environmental impact, safety of traffic operation, providing infrastructure, town and city’s planning and knowledge enhancement which are classified based on stakeholders in Table 1.

Table 1. Objectives of urban freight studies

Objective	Description	Key stakeholders
Reducing Cost	Minimization or reduction in transport operation costs	Supplier and Carrier
Improving efficiency	On time delivery, loading- unloading, parking of freight vehicles	Receiver and carrier
Environmental impact	Noise and air pollution caused due to congestion of urban roads	Administrator and residents
Safety of traffic operation	Reduction in the number of accidents and damage to property and life caused	Residents, Administrator
Providing infrastructure	Road construction and maintenance, provision for parking and transport hubs	Administrator and carrier
Town and city planning	Urban and logistics sprawl occurring in the city over years	Administrator
Knowledge enhancement	Some studies are carried to enhance knowledge which can be implemented at a later stage	Administrator and research community

2.5 Survey Methodology

Depending upon the objective of the study and stakeholders considered in the study, the methodology adopted is bound to change. Also study area size is one of the very important factors for deciding the type surveys to be conducted. In cities of developed economies that have custom made models suiting to their freight flow pattern and data availability. But for a country like India where such studies are is yet in nascent stage, continuous and reliable data of freight flows are quite difficult to obtain. Different researchers have adopted different survey methods in their capacities and need for their research work [14]. Based on the several review papers studied the survey methods which are proved to efficient and effective in freight research elsewhere are listed belo:

- Establishment survey,
- Roadside interview survey,
- Commercial vehicles driver survey,
- Volume count survey,
- Supplier’s survey,
- Commodity flows,
- Freight operator or service provider’s survey,
- Parking inventory survey,
- Vehicle trip diaries,
- Secondary data sources.

Depending upon the scale of project more than one survey method may be needed for capturing the required information. Secondary data sources are also used for collecting information which is relevant to the study. Each

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of the above methods has their own advantages and limitation. These survey methods sometimes offer a trade-off between data accuracy and cost of data collection. Data collected during these methods may sometime overlap, which can be used as a cross-check of the data collected during the survey.

the overall social cost of goods transportation and making urban freight more sustainable. Depending upon the key stakeholders involved in the study, the application of the work can be sometimes restricted to a particular section. At city level the application any freight study can be divided into four types, which can also be considered as four divisions defining the overall social cost of moving goods.

2.6 Applications of the study

As stated earlier from a researcher’s point of view the primary purpose of any freight research study is to reduce

Table 2 Review results of urban freight studies in India

Sr.	No.	Author details	No of C/S		Study area						Stakeholders						Objectives										Survey methodology										Application	
			Single commodity/service	Multiple commodity/service	Single street or market area	City or metropolitan area	Multiple cities comparison	Administrator	Supplier	Carrier	Receiver	Residents	Reducing Cost	Improving efficiency	Environmental impact	Safety of traffic operation	Providing infrastructure	Town and city planning	Knowledge enhancement	Establishment survey	Roadside interview survey	Drivers' survey	Volume count survey	Suppliers survey	Commodity flows	Freight operator's survey	Parking inventory survey	Vehicle trip diaries	Secondary data sources	Upgrading traffic policy	Suggestions for planning	Urban development	Urban and logistics sprawl					
1		Kumar <i>et al.</i> [24]	✓				✓																															
2		Guttikunda & Kopakka [25]	✓				✓																															
3		Baindur & Macário [26]	✓				✓																															
4		Swamy & Baindur [27]		✓			✓																															
5		Divya Priya <i>et al.</i> [28]		✓			✓																															
6		Datta & Gupta [29]		✓			✓																															
7		Bakshi <i>et al.</i> [30]		✓			✓																															
8		Sadhu <i>et al.</i> [31]		✓			✓																															
9		TCI – IIM [32]		✓			✓																															
10		Gargava & Rajgopalan [33]		✓			✓																															
11		Baveena [34]		✓			✓																															
12		Goyal [7]		✓			✓																															
13		Kin <i>et al.</i> [16]		✓			✓																															
14		Gupta [35]		✓			✓																															
15		Gupta & Garima [36]		✓			✓																															
16		Malik <i>et al.</i> [37]		✓			✓																															
17		Pani <i>et al.</i> [38]		✓			✓																															
18		Bhardwaj <i>et al.</i> [39]		✓			✓																															
19		Sethia [40]		✓			✓																															
20		Bakshi <i>et al.</i> [41]		✓			✓																															
21		Erampalli <i>et al.</i> [42]		✓			✓																															
22		Erampalli <i>et al.</i> [43]		✓			✓																															
23		Gupta and Sinha [44]		✓			✓																															
24		Pani & Sahu [45]		✓			✓																															
25		Pani & Sahu [46]		✓			✓																															
26		Pani & Sahu [47]		✓			✓																															
27		Pandya <i>et al.</i> [48]		✓			✓																															
28		Dhonde & Patel [49]		✓			✓																															
29		Dhonde & Patel [50]		✓			✓																															
30		Dhonde & Patel [51]		✓			✓																															
31		Dhonde & Patel [52]		✓			✓																															
32		Middela <i>et al.</i> [53]		✓			✓																															
Total			6	26	0	21	10	10	10	14	6	4	5	16	13	4	3	3	12	14	0	7	5	1	6	15	2	2	13	15	16	9	2					

- Upgrading traffic policy; the outcome of study results in or acts as a guideline for improving traffic policy in the study area. (example; Implementing traffic restriction for heavy commercial vehicles (HCVs) during peak hours)
- Suggesting planning principles; the study can develop analytical models which can guide planning decision of

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city officials. (example; Infrastructure planning decisions like parking places and road planning)

- Adopting new technology; with use of geographic information systems (GIS) and global positioning system (GPS) technology and other intelligent transport systems (ITS) technologies, real time traffic and congestion status can be known which can improve efficiency of urban goods movement.
- Urban and logistics sprawl; temporal studies carried out for different times can help understanding the sprawl of city and logistics infrastructure like warehouse or consolidation centers, which in turn can help in long term city planning schemes.

Refining searches from various sources a total of 32 papers were selected for the review process. Each stage of the review process was carried out for each of these papers and review results have been summarized in table 2.

3 Review results and interpretations

Summary of research studies on urban freight transport carried out in India is presented in Table 2. The review is carried out based on six major parameters, number of commodities and/or services, study area and size, stakeholders, objectives of the study, and survey methodology and applications of the study. A total of 32 research works found from reliable and recommended sources are reviewed. Some other works found in local level publications and conferences which indicate only data collected for existing scenario of urban freight and any significant research outcomes are not observed, hence such works are omitted from the study to ensure that only quality works are considered to define the state of art for urban freight studies in India. The results of the review process and its interpretations are discussed in this section.

Number of services or commodities considered for the study considerably affects the research methods adopted. To assess the overall impact of UFT on the city's traffic it is necessary to consider all goods and services involved, however due to the limitations of availability time and resources it is very difficult to collect data for all the commodities and services of the city. However, in cities where some particular industry has very dominant presence and are generating majority of the urban freight trips, study of those particular commodity or service can prove to very useful. Six such studies have taken a specific commodity or service like municipal waste, timber etc, which are useful in planning of specific infrastructure sometimes not related to transportation, waste treatment plant or sawmills for instance [26-49]. Such studies can reduce the cost of data collection and yet give reasonably well results. More such studies focusing on freight movement of perishable goods and hazardous goods.

For the second parameter i.e. size of study area, it is observed that 21 out of 32 (2/3rd) studies have considered entire city as the study area, while none of the studies have

done micro-simulation or meso-simulation considering the freight impact of a single unit or a small area in the city, such studies have been very useful in solving urban freight issues in some cases [50-54]. A good number of studies have been conducted comparing different studies, which is a positive step towards designing nationwide policy of urban freight transport. Studies focussing on microscopic and mesoscopic level simulation of UFT are already conducted in cities of developed countries but are still not carried out for Indian cities.

Overview of stakeholders representation in the review suggest that administrators, shippers and carriers have greater contribution towards freight studies as compared to receivers and residents or end-consumers of the city. The role of administrator, directly or indirectly, comes into picture once the actual implementation of any research study is carried out in the city. There are some studies wherein role of carriers is independent of the administrator for example the case study of dabbawala's of Mumbai [27] and textile goods [52]. Suppliers are having more impact on the urban freight movement as compared to receivers. For majority of the commodities the responsibility of delivery of goods or services lies with suppliers. In case of UFT suppliers of goods and services are the wholesale and retail establishments in the city. The studies that are basically conducted to assess the environmental impacts of urban freight in the form of noise and air pollution have residents of the city as they key stakeholders.

Objectives of any UFT study needs to be very clear and well defined owing to its time and resource requirements. In the present study, seven major objectives of urban freight transport are considered in the review framework. These objectives are selected based on the framework from Odgen and Crainic [21,22] and as well as their relevance for the studies carried out in India; it is quite possible that in future some more objectives might be added in the list with development in technology and higher demand of frequent and timely deliveries. Most of the studies have shown that achieving efficiency in the system is the most important objective. Environmental impact of urban freight is the second most important objective; with India having some of the most polluted cities in the world it is not very surprising. Safety of traffic operation is a very major issue in India both for freight and passenger traffic leading to several accidents every day. Studies carried out in India are found very premature to give serious recommendations for infrastructure and town planning, lack of systematic and detailed land use data is one of the prime reasons behind it.

A review of survey methodologies adopted by various studies in India clearly indicate that establishment survey, freight transport operators' survey and secondary data are the most preferred methods. Establishment survey and freight operator's survey are the two tools which are more or less in control of the researcher and hence are the most reliable method for data collection. Secondary data sources are more useful obtain aggregate and periodic data; hence it is more useful for studies which are a sort of comparative

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analysis of two or more cities. Drivers' survey, commodity flow survey and traffic volume count are also used by some researchers, this methods of data collection are more suitable when the study are is small or study is restricted to particular commodity or service. Parking inventory and vehicle trip dairies data have limited scope in Indian scenario as the urban freight transport business is dominated by light commercial vehicles (LCVs) operating in a almost uncontrolled or unregulated manner [51]. Use of freight vehicles parking infrastructure is not done effectively and efficiently in many cities of the country and hence parking inventory data is not considered to be very reliable. Roadside interview method of data collection is not used in any of the study during the review; this survey tool has very limited application in urban freight studies across the world.

The last section of the review process accounts for the application of each study. Reducing the overall social cost of urban freight movement in the study is the ultimate goal of UFT studies in general, which is however categorized into four different applications as discussed in the sub-section on application of the study. Review results indicate that majority of the studies comes up with different suggestions that can improve the traffic policies (14 nos.) and freight transport planning (15 nos.) in Indian cities, and two studies focussing on urban or logistics sprawl. It is quite disappointing to find that none of the studies are considering technology improvement as a solution approach for city logistics related problems. Improving urban goods movement using latest technologies for vehicle routing and availability of real-time information about the road network are a common practice in developed economies nowadays, which is a distant future practice in India it seems. Private players like Amazon and Flipkart are using latest technologies for routing delivery trips and real time status, however such case studies aren't considered in the review due to lack of documented evidence.

4 Conclusions and suggestions

From the review it is also found that in India, majority of the research work on urban freight transport is carried out only in the last decade. However, the pace at which the interest of researchers is growing in this area is very encouraging. Based on the results obtained by different researchers in their respective efforts and some concluding comments made by them, authors have tried to present some concluding remarks and suggestion for future research in urban freight.

4.1 Conclusions of the study

It is a very good sign for the cities of India that more and more researchers are developing interest in field of urban freight studies, but there is still a long way to go for solving various problems UFT systemes that cites in India are facing. From the present study it can be concluded that one of the major reasons limiting research effort in this

direction in lack of systematic data collection related to urban freight in India. Unlike passenger transport, freight transport is not having a special cell or department looking after its growth and development in cities of India. Secondary data sources or urban freight transport are non-existent. In such a situation only premier institutes in the country like IITs and IIMs are able to make more efforts with their relatively larger impact. Most of the researches that have been carried out in the country are more or less only dependent on the primary data sources, which are very costly and time consuming. In absence of reliable secondary data sources, primary data collection consumes a lot of time, reducing the relevance of the research findings in some cases. Primary data collection gets very difficult with establishment becoming hesitant in sharing information owing to trade secret and tax hues. Collecting data from freight transport operators is relatively easy but for most of the major cities in India, urban freight transport is largely managed by LCVs, which are operated by individual vehicle owner like taxis and hence the movement of LCVs is literally haphazard and non-regulated. The brighter part of the study is that now researchers and policy makers have realized that urban freight is a very significant contributor to the overall traffic in terms of its impact on congestion and urban environment. Gradually, it has been widely accepted that considering freight vehicles as some proportion of the overall traffic is a very gross approximation and not advisable reference for taking crucial decision involving huge amount of resources and time.

4.2 Suggestions for future research

There is an ample scope for improvements in the existing urban freight transport systems in the country and the insights gained from this review article would probably help many researchers and practioners to drive their future research endeavours in this direction. Based on the knowledge gained during reviewing the existing studies and the conclusions put forward, following are some suggestions by the authors for future research in urban freight transport in India

The review factors of the frameworks - number of commodities/ services, size of study area, stakeholder, objectives, methodology and application approach - are all interconnected and understanding these interconnections in a city's UFT system would be very useful in identifying research needs. From the review process some of the factors are found to be unexplored in Indian conditions, for instance microscopic simulation of urban freight generation or application of intelligent transport systems for UFT. Such gaps need to be filled in quickly for setting up a concrete foundation for future research. It is also observed during the study that majority of the studies are carried out in megacities only i.e. Delhi and Mumbai, however it is equally important to have efficient systems in other metros and medium size cities of the country. City specific or goods specific models needs to be developed as

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a medium term goal for each city supporting long term decision making process for investment in urban freight infrastructure of the cities. In long term, India should be able to come up with its own urban freight transport development manual guiding every aspect of urban freight transport like trip generation, infrastructure planning and freight transit oriented development in cities of the country, similar Institution of transportation engineers (ITE) guidelines and highway capacity manual (HCM). For achieving success in making urban freight movement more sustainable support and cooperation from all the stakeholders is inevitable. Sustainability and efficiency cannot come from one sided efforts by administrators alone. Stakeholders perception studies needs to be carried out before implementation of any policy.

During the review process, several research and review articles of the work carried out in USA, Europe and Japan were studied for understanding the progress of UFT research in those countries and find a comparison for studies carried out in developing countries. From some articles studied during the review process, some more innovative suggestions are given for new research avenues of urban freight which are probably unexplored in developing economies so far. The concept of circular economy which is largely restricted to manufacturing industry is now being implemented as a solution in urban freight for reducing the overall cost and environmental impact of good movement. This concept fundamentally proposes to reduce, reuse and recycle the waste of any process to improve sustainability (Genovese et. al., 2015; van Buren et.al., 2016). Most of the cities of developing countries are more congested and have mix land use patterns, LCV trips carrying small quantities for short distances often makes higher contribution to the overall freight trips. If electric freight vehicles are used for such trips, a lot of burden of noise and air pollution can be removed (Browne et. al., 2011; Van Duin et. al., 2013; Gruber et. al., 2014). Also shared private vehicle trips similar to models adopted for passenger transport like Uber can be adopted for urban freight transport. Sharing of freight trips would enhance productivity and reduced pollution at the same time (Patier et. al., 2014; Marcucci et. al., 2017). As mentioned earlier in the study, use of GIS and GPS technologies can be used for real time tracking of freight vehicles as well as geo-tagged parcels. These technologies are already in place for long distance or regional transport by various logistics providers, however its application in urban freight is very limited yet (Yang et.al., 2014). With more and more shopping going online and geo-tagging of vehicles, use of big data for user preferences can synchronize urban goods movement with several other infrastructures involved making goods flow smooth, easy and sustainable. The distribution and utilization of urban spaces in developing economies are entirely a different ball game as compared to the developed economies. Each and every aspect of urban freight needs to be studied from the perspective of developing countries

to fill in various research gaps discussed in this paper. This review paper definitely help the researchers and policy maker to ponder in the research gap identified with the limitation of developing countries. Collaborative efforts from the research and urban administration fraternity should try to meet at one platform and endeavours to develop a think tank or special interest group which can work together for sustainable urban freight studies.

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Review process

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