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IMPACT ANALYSIS OF URBAN FREIGHT TRIPS GENERATED FROM WHOLESALE MARKET, AHMEDABAD

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Keywords: freight trip attraction, freight trip production, freight transportation, SPSS, wholesale market.
Abstract: Freight transport plays an important role in meeting the domestic needs of the city's inhabitants. But when freight vehicles come into contact with city traffic, it has a negative impact on urban routes, such as extra traffic congestion, noise pollution, air pollution, etc. The aim of the study is to assess the impact of freight transport on the overall traffic of the city. A case study of the wholesale market of Ahmedabad has been considered as a study area. The freight trip models based on the trips attracted and produced by the market are developed on the basis of data collected from establishment surveys and freight vehicle driver surveys. Both the models developed in this study, FTA (Freight Trip Attraction) and FTP (Freight Trip Production), have R Square values of 0.799 and 0.715, respectively. The volume of freight vehicles contributing to the overall traffic flow is also measured by the traffic volume study. Through the data analysis and identification of the impact of freight transportation on city traffic, remedial measures are discussed to reduce the impact of freight transportation.

1 Introduction

The development of the transport system is essential for the economic development of the country. For this, the movement of passengers and goods should be safe and efficient. Along with the movement of passenger traffic, the movement of goods on the road network is equally important in both urban and rural areas. Society cannot sustain economic development without the smooth movement of the freight transport system. Due to the changing lifestyles of our society and technological advancement, there is a possibility of significant growth in freight transport in the future. However, it also has a negative effect on our daily lives, such as traffic noise on urban routes, air pollution, and creating additional traffic congestion. The movement of goods within a town or city generates a substantial demand for road space and parking facilities. According to MORDOR Intelligence [1], the transport industry contributes about 6.3% of the GDP and is dominated by the road sector. More than 50% of freight and 90% of passenger traffic is controlled by roads. According to the Road Transport Yearbook 2018-2019 by MORTH [2], the total number of transport vehicles has increased from 23.97 million in 2017-18 to 25.89 million in 2018-19. The newly registered transport vehicles in 2018-19 is shown in Figure 1. From the study, actual freight transport patterns and modes of freight transportation used in the market can be identified, new guidelines for improvement and necessary policy changes can be made [3]. The study helps in urban planning and the development of a framework for sustainable freight transportation. The objectives of this study are to develop a model for measuring the number of trips produced and attracted by the market; the impact of freight vehicles on the overall market traffic is analyzed, and remedial measures are suggested to reduce the impact.

The study was carried out at Gheekanta wholesale market, Ahmedabad a city in India. The multilinear model was developed in this study to estimate freight trip attraction and production by market. An establishment survey and a freight vehicle driver's survey were carried out in the market to collect data. The number of freight trips attracted by the market depended on the quantity of goods arriving in the shop in a day, the average floor area of the shop, and the distance between the origin and destination of the trip. The amount of freight produced by the market depended on the distance between the origin and destination of the market and the number of employees in the shop [4-5].

The paper consists of six sections, i.e., Introduction, Literature Review, Study Area, Methodology, Data Analysis, and Results, Conclusions. Introduction sections provide general information about freight transport and its negative effects. The literature review highlights past studies on freight transport. The study area sections provide general information about the Gheekanta wholesale market, Ahmedabad. In Methodology, the steps for conducting the study is given. In this study, an establishment survey, a freight vehicle driver survey, and a

traffic volume study were conducted. In the Data Analysis and Results section, multiple linear regression is used to estimate the trips attracted and produced by the market. As well as the amount of freight traffic in the total market traffic is analyzed. And market parking conditions are also analysed. After the analysis section, the findings of the study and recommendations for improvement are given.

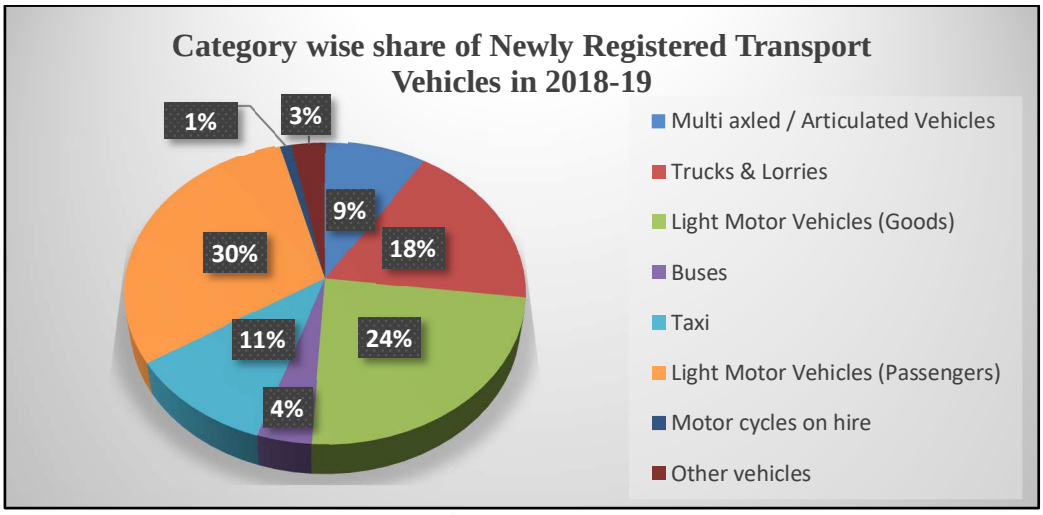


Figure 1 Category wise share of newly registered transport vehicles in 2018-19

2 Literature review

Bhavesh Dhonde (2021) [6], This paper presents a review of urban freight studies carried out for different cities in India. The purpose of this paper is to identify and analyse the factors inhibiting research on urban freight transport in developing countries like India. From the study, it is found that the number of services or commodities considered for the study considerably affects the methods of freight research and that, to study the overall impact of urban freight transportation on city traffic, all the goods and services that generate freight trips need to be considered. But the study on specific commodities or services gives reasonably good results and also reduces the cost of the data collection. Establishment surveys, freight transport operators' surveys, and secondary data are the most preferred methods for data collection in developing countries.

Agnivesh Pani and Prasanta K. Sahu (2019) [7], This paper analyses the non-response behaviour in freight surveys. The study was carried out in Kerala, India by conducting an establishment-based freight survey (EBFS). The aim of the research is to enhance the current knowledge about the concerning patterns in non-responsiveness. Results of the study show that the industrial classes handling commodities with high-value density exhibit a high non-response probability for freight surveys. This may be due to the fact that establishments handling high-value products tend to be less attentive to logistics strategies or have higher capital and opportunity costs associated with these commodities, and therefore, their information tends to be more proprietary in nature. The results also show that the location of the establishment also affects non-response behavior. Establishments near ports with a high per capita income are less likely to respond to the survey.

Khalid Aljohani and Russell G. Thompson (2016) [8], This paper represents the literature review of the various impacts of logistics sprawl, providing a detailed taxonomy. Not only does the location of logistic facilities affect urban goods movement, but it also has an impact on the urban environment. Paper represents the main two factors that contribute to the relocation of logistics facilities. The first is land use, and the second factor is new operational and location requirements. The paper mentions the impacts of logistics sprawl, such as the impact on urban freight geography. increased distance travelled by trucks and it creates negative impacts on the environment.

Bhavesh Dhonde and Chetan R. Patel (2021) [9], The study aims to assess the impacts of the city's geographic sprawl on urban freight transport in the Surat textile industry. An establishment survey was conducted at weaving units in various textile manufacturing clusters in the city. Trips are calculated based on the factors affecting trip generation for which a multi-linear regression model was developed. The total number of trips generated depends on the total number of weaving machines, the total floor area, the total number of employees at the unit, and the type and capacity of the vehicle used for transportation.

3 Study area

The Gheekanta wholesale market, Ahmedabad is taken as the study area (Figure 2). Gheekanta is the wholesale market for readymade garments. There are about 1000 shops in the market. The market acts as a distribution

centre. Readymade garments come into the market and are sold at wholesale prices after packing and labelling. This market receives goods (textiles) from Ahmedabad as well as states like Delhi, Mumbai, and Rajasthan. These goods are sold in Ahmedabad, Gujarat, and all over India. The market opens between 10 and 11 a.m. and closes between 7 and 8 p.m. the market is very old, the streets are narrow, about 7-8 m. Therefore, large freight vehicles like Light Commertial vehicles (LCVs) and Heavy commertial vehicles (HCVs) cannot enter the market. Small commercial vehicles are used to transport goods such as three-wheeler rickshaws, three-wheeled bicycles, and two-wheelers.

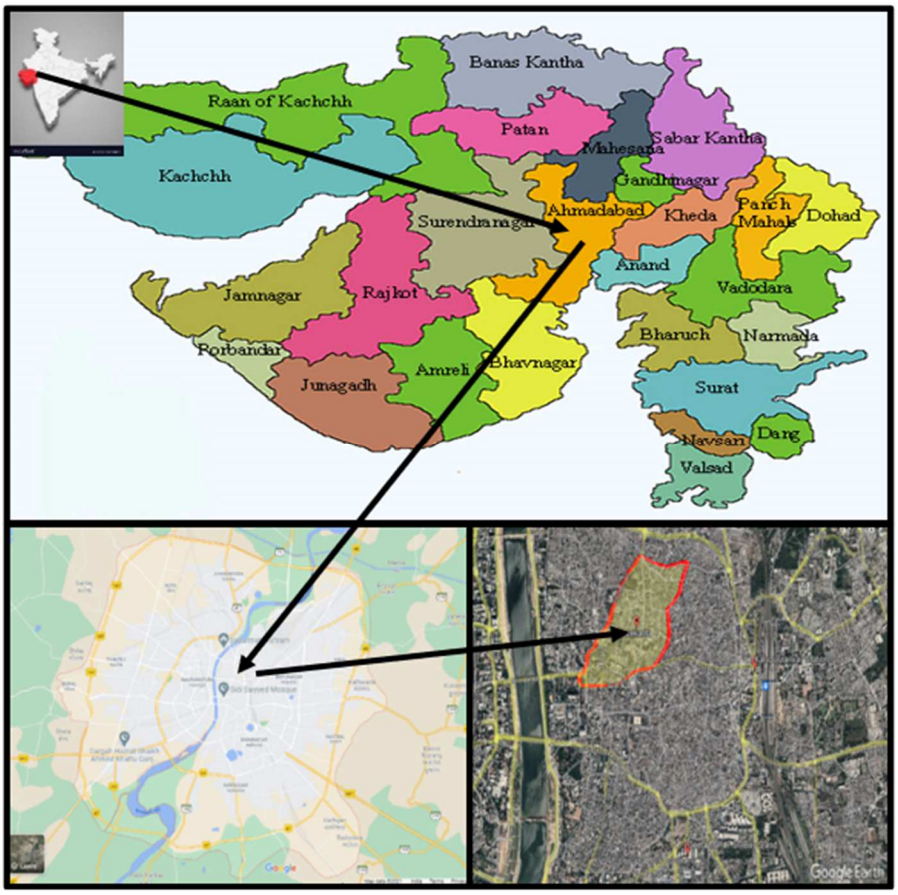


Figure 2 location of Gheekanta market

4 Methodology

The proposed methodology involves various steps to achieve the aim of the study. First, the problem is identified, and the need for the study is also identified. The aim and objective of the study are selected. Studies carried out in the past according to the study topic are found and studied. Data collection needs to be carried out in the study area. In terms of data collection, three surveys are planned for the study. The first is the establishment survey. In the establishment survey, a survey form is made to get information about the shops in the market. How many quantities of garments are coming and going from each shop in the market is also found out. The form can also provide information about the workers working in the shop and the owner, e.g., where workers and owners come from and which mode of transport they use and where they park their vehicles if private vehicles are used to come to the market. The second survey is the freight vehicle driver's survey. The survey provides information about where goods come from in the market and where they go from the market. It also gives information about the parking facilities for loading and unloading of goods in the market. The third is the traffic volume survey, which gives the number of vehicles coming and going from the market in a day. It is carried out at six different location as shown in Figure 3. After the data collection, this data needs to be analyzed. The supply chain process of the market, the multi-linear regression model to estimate freight trips attracted and produced by the market, and the goods loading and unloading scenarios in the market are understood in the data analysis stage. From the above data analysis, the effect of freight traffic on other traffic in the market is derived. From the result, the conclusion will be carried out, and suitable recommendations will also be provided to improve the condition of traffic.

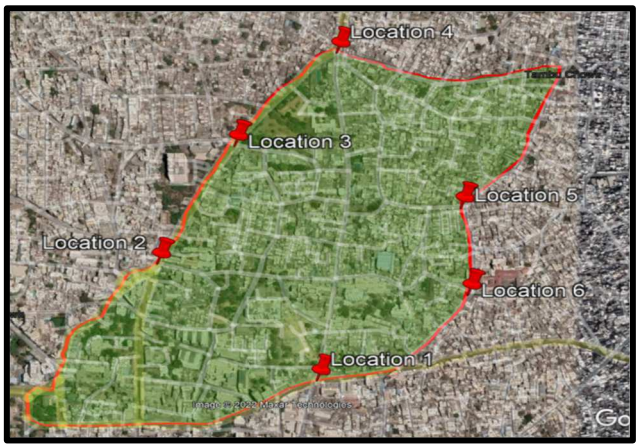


Figure 3 Survey location for traffic volume study

5 Data analysis and result

5.1 Supply chain process of market

The market works like a distribution unit. In this market, ready-made garments are labelled, packaged, and sold to other customers at wholesale prices. The supply chain process of the market shown in Figure 4. The garments coming into the market mainly come from other states like Delhi, Mumbai, Rajasthan, etc. and Ahmedabad based textile companies. Garments that come from other states are transported to Ahmedabad by train or bus, which are procured by the local transport offices and then taken to the market by rickshaw or pedal rickshaw. These transport officers are mainly located at Kalupur, Raipur, Madhupura, Premdarwaja, Saranpur, etc. And the clothes that are made by the textile company in Ahmedabad are taken to the market with the help of rickshaws or pedal rickshaws from the company. Similarly, the garments sold in the market are transported by rickshaw or pedal rickshaw if they are sold in Ahmedabad. If it is sold in other states like South India, Maharashtra, Kolkata, Madhya Pradesh, etc., then the goods are delivered to the transport office by rickshaw or pedal rickshaw, and from there the goods are transported by train and bus.

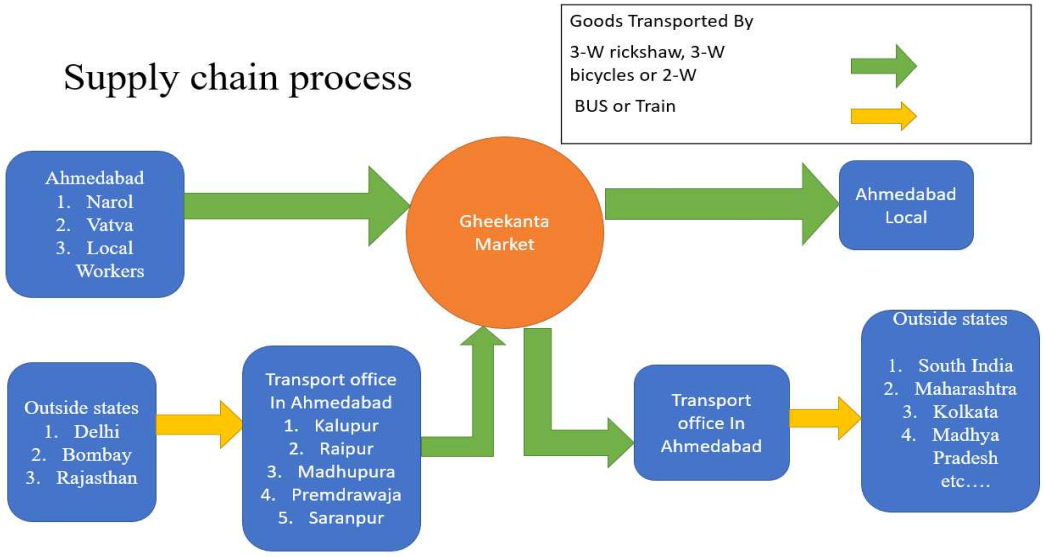


Figure 4: Supply chain process of Gheekanta market, Ahmedabad

5.2 Estimation of freight trips from Gheekanta market

Establishment survey data is used to estimate the freight trips generated and attracted by the market. Multi-linear regression (MLR) models have been developed to estimate freight trip generation and attraction.

5.2.1 Freight trip attraction model

The freight trip attracted by any shop mainly depends on the quantity of goods arriving, the floor area of the shop, and the distance between the shop and the transport office. Therefore, for this FTA model (freight trip attraction), the trips attracted by any shop are treated as a dependent variable, and the quantity of goods arriving in the shop, the floor area of the shop, and the distance between the shop and the transport office are treated as independent variables. The correlation between these dependent and independent variables is given in Table 1.

Freight Trip Attraction Model

$$FTA = 2.5136 + 1.206\,(Q) + .0176\,(A) - 0.2191\,(D) \quad (1)$$

Where:
FTA is the Freight trip attracted by any shop in the Gheekanta market.
Q is the Quantity of goods arriving in the shop in a day (numbers in thousands).
A is the average floor area of the shop (in square meter).
D is distance from the Origin of the trip (transport offices) to the Gheekanta market (in km).

Table 1 Correlation matrix for freight trip attraction model

	Trip Attracted by shop	Quantity of goods Coming in shops (In number)	Avg. Area of shops (m^2)	Distance between transport office and market (km)
Trip Attracted by shop	1			
Quantity of goods Coming in shops	0.303*	1		
Avg. Area of shops	0.386**	0.337**	1	
Distance between transport office and market	-0.794**	-0.097	-0.223	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Pearson correlation between dependent and independent variables was found to be moderate positive/Negative correlation and statistically significant ***(P <0.05)***.

The statistical parameters for the FTA model are given in Table 2. The table shows that the significance F value and P-values are less than the critical values (0.05). which indicates that the model can significantly predict the number of trips.

Table 2 Statistical parameters of FTA model.

	Coefficients	Standard Error	t Stat	P-value	F	Significance F	R Square
Intercept	2.513	0.296	8.475	8.62E-12	46.876	1.26E-15	0.704
Quantity of goods coming to shop	1.205	0.512	2.353	0.022			
Avg. Area in meter	0.017	0.008	2.102	0.040			
Distance from shop to market	-0.219	0.021	-10.204	1.20E-14			

The model has an R Square value is 0.704, which indicates that the model explains 70.4% of the variance in the dependent variable. The model equation also explains the positive relationship between the quantity of goods arriving in the shops and the average floor area. This means that if the shop has more floor area, they order more goods, and the number of trips increases as all the goods are transported by 3-rickshaw or pedal rickshaw. There is a negative correlation between freight trips and distance, which means that for longer distances, more time is required, and because of delays caused by traffic, drivers make fewer trips than short-distance deliveries.

5.2.2 Freight trip production model

The freight trip produced by any shop depends on the number of employees in the shop and the distance between the market and the transport office. For the FTP model, the trip produced by any shop depends on the number of employees working in the shop and the distance between the market and the transport office. The correlation between these dependent and independent variables is given in Table 3.

Freight Trip Production model

$$FTP = 2.5114 - 0.5497\,(D) + 0.5056\,(E) \quad (2)$$

Where:
FTP is the freight trip produced by the shop in Gheekanta market.
D is the distance between market and transport office (in km).
E is the number of employees in the shop (in numbers).

Table 3: Correlation matrix for freight trip production model

	Trip produce by shops	Distance from shop to transport office (km)	No. of employee working in shop (in numbers)
Trip produce by shops	1		
Distance from shop to transport office	-0.756**	1	
No. of employee working in shop	0.722**	-0.528**	1

Pearson correlation between dependent and independent variables was found to be moderate positive/Negative correlation and statistically significant ***(P <0.001)***.

The statistical parameters for the FTA model are given in Table 4. The table shows that the significance F value and P-values are less than the critical values (0.05). which indicates that the model can significantly predict the number of trips.

Table 4 Statistical Parameters of FTP model

	Coefficients	Standard Error	t Stat	P-value	F	Significance F	R Square
Intercept	2.511	0.441	5.690	1.19E-06	51.557	6.43E-12	0.715
Distance	-0.549	0.103	-5.299	4.27E-06			
Employee	0.505	0.110	4.558	4.58E-05			

The model's R Square value is 0.715, which indicates that the model explains 71.5% of the variance in the dependent variable. The model shows the positive relationship between the number of trips produced by the shop and the number of employees. That means if the number of employees is increased, they can deal with more customers, resulting in the sales of the shop increasing and trips also increasing. The model shows a negative relationship between the trip produce and the distance between the market and the transport office.

5.2.3 Model validation

The FTA and FTP models are validated by survey data. The data from 10 shops is randomly selected for the survey data, and the values of independent variables are placed in the model to validate the model. Trip estimates by models are approximately the same as the actual trips. So, these models can estimate the true number of trips coming and going from the shop. With the help of these models and the data of the shop, the trip generation and attraction from the shop can be estimated. This can be useful for urban planning and developing a framework for sustainable freight trips.

5.3 Traffic study at Gheekanta market

As discussed in the Traffic Volume Survey, the traffic survey was conducted at six different locations in the market from 8 a.m. to 9 p.m. From the survey, the number of vehicles (freight or passengers) that visited the market on any given day is calculated. Also, category-wise distribution of various vehicles is carried out. The volume of freight vehicles in the overall traffic is also calculated. Vehicles are multiplied by Passanger Car Unit (PCU) values to convert all types of vehicles into one unit. The PCU values of different types of vehicles are shown in Table 5. PCU values are as per IRC 106-1990 [2].

Table 5 Recommended PCU factors for various types of vehicles on urban roads

Sr No.	Vehicle type	Equivalent PCU Factors
1.	Two wheelers Motor	0.75
2.	Passenger car	1.0
3.	Auto-rickshaw	2.0
4.	Light commercial vehicle	2.0
5.	Truck or Bus	3.7
`6.	Cycle	0.5
7.	Cycle rickshaw	2.0
8.	Hand cart	3.0

As per (Indian Road Crogress) IRC 106-1990

5.3.1 Total trips from the Market

The total trips coming in and out of the market are shown in the Figure 5. Trips of freight vehicles such as 3-wheeler rickshaws and 3-wheeler pedal rickshaws and trips of passenger vehicles such as 4-wheelers, 2-wheelers, passenger rickshaws, and bicycles are considered as total trips. In the market the peak hours of the traffic are between 12:00 p.m. and 1:00 p.m. The Table 6 shows the total volume count of inflow and outflow from the market in PCU/day. Location 2 has the highest inflow and outflow it is because Gheekanta court is located near the location 2.

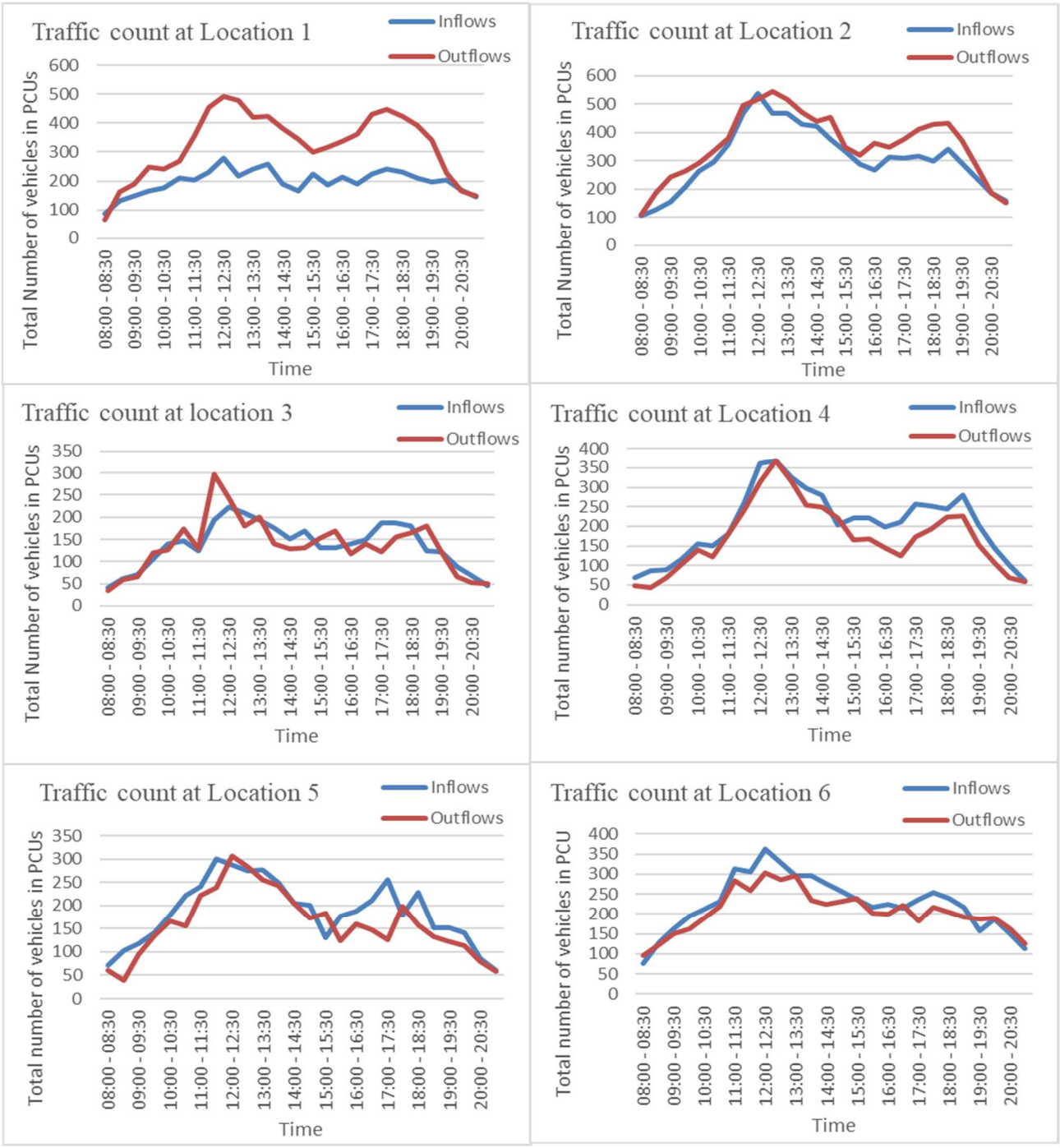


Figure 5 Traffic volume count of total trips at different six locations

Table 6 Total volume count in PCU/day

Location	Inflows (PCU/Day)	Outflows (PCU/Day)
1	5140	8417
2	8020	9266
3	3567	3524
4	5344	4482
5	3989	3523
6	4958	4826

5.3.2 Total Freight trips from market

The total freight trips produced and attracted by Gheekanta Market are shown in Table 7, in which only trips of freight vehicles are considered. The passenger 3-wheeler used for goods transport is also being considered. 2-wheelers are also used for goods movement in the market, but they are not included. The Figure 6 show freight trips from different locations throughout the day. Trips for freight vehicles begin around 9 a.m. And after 9 p.m., the trips go to zero.

The road that connects Location 4 and Location 1 is the central road that runs through the market, and most of the shops in the market are located on this road. Trips from other places are few compared to these two places. The market has a narrow road of about 7-8 meters. As a result, congestion occurs frequently on this road. This is the busiest street in the market.

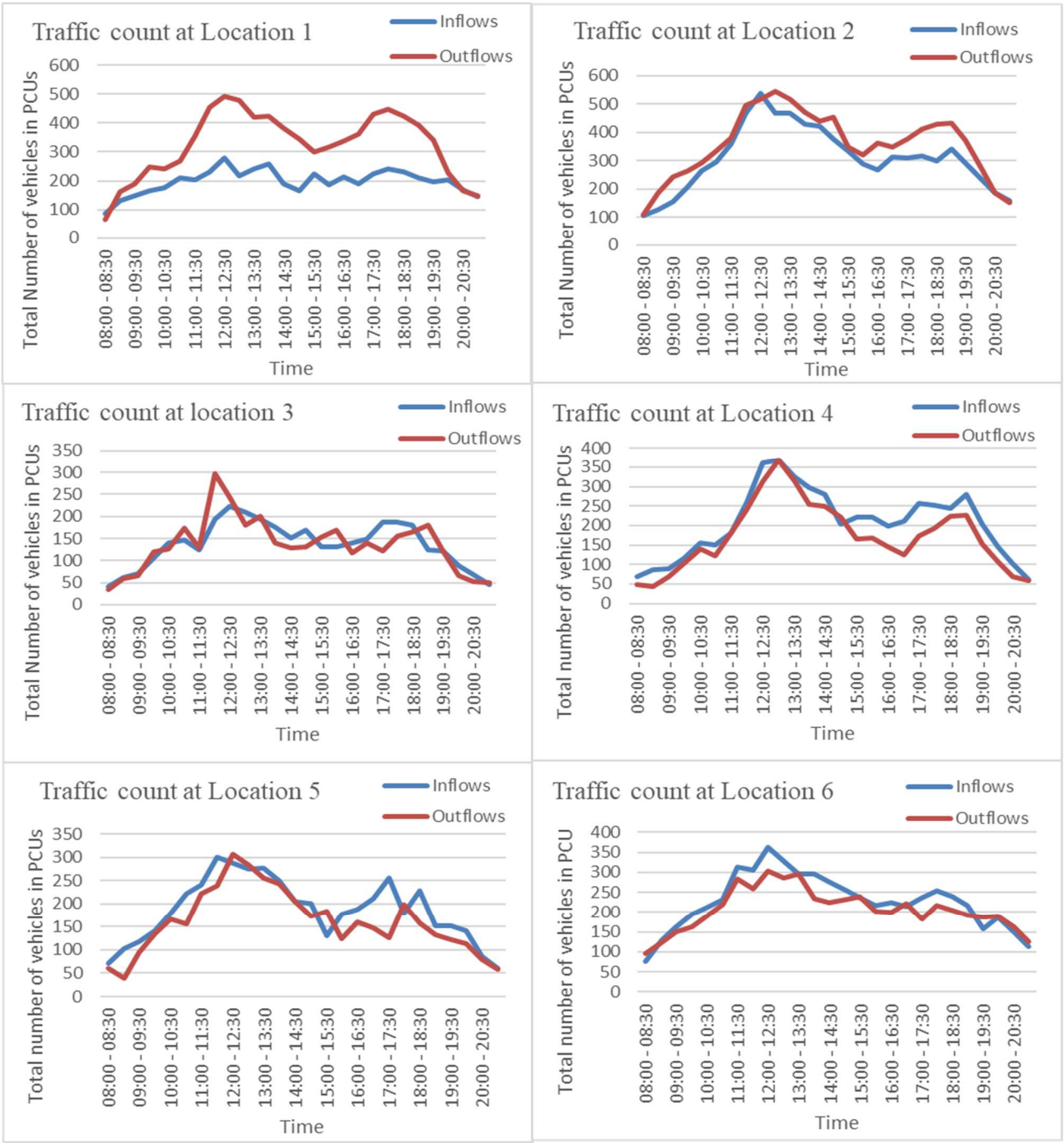


Figure 6 Total Freight trips at different six location

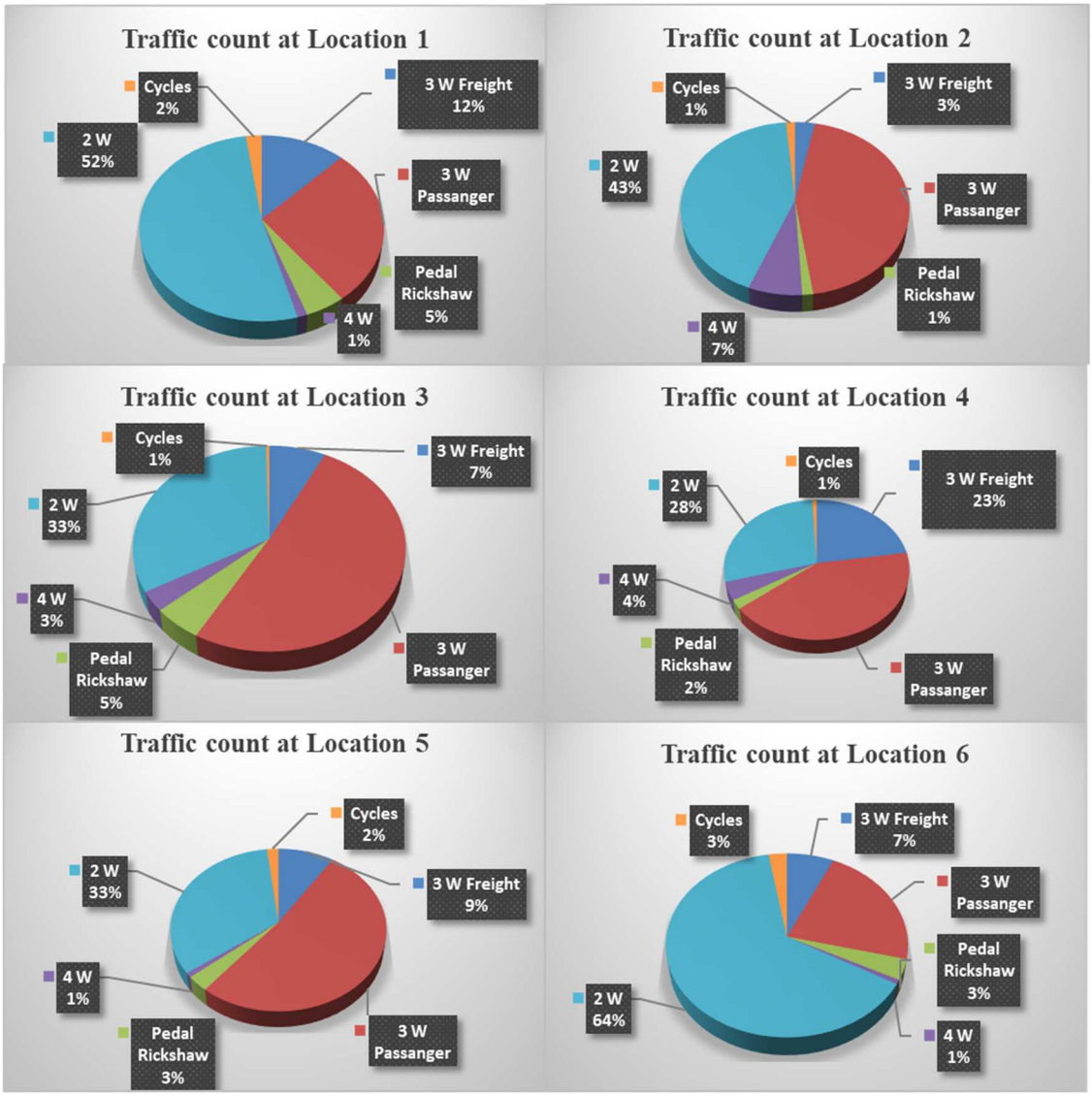
Table 7 Total fright trip incoming and outgoing from the market

Location	Inflows (PCU/Day)	Outflows (PCU/Day)
1	1034	1292
2	368	404
3	440	444
4	1330	1092
5	570	512
6	590	438

5.3.3 Category-wise distribution of traffic

Locations 1 and 4 show a higher percentage of freight vehicles than other locations, which is about 18% to 25%. In distribution (Figure 7), 2-wheelers have the highest percentage, averaging 43%. The 2nd highest percentage of passengers is 3-wheelers, which is 40% on average. The passenger 3-wheeler is mostly used by visitors. The use of 4-wheelers in the market is very low.

In category wise distribution, non-motorised vehicles, that is, pedal rickshaws, which are used for freight transport, have a very small percentage. But non-motorized vehicles like pedal rickshaws cause congestion in the market as their speed is slow, so they slow down other motor vehicles following them. Due to the narrow road, motorised vehicles cannot overtake pedal rickshaws. As a result, long queues are formed.



(Abbreviation : 2 W:- 2 wheeler, 3-W:- 3 wheeler, 4 W:- 4 wheeler)

Figure 7 Category-wise distribution of traffic

5.3.4 Loaded vs Empty Freight trips

In the market, if a freight vehicle comes to drop off goods, it may be emptied on return. In the same way if a freight vehicle takes goods from the market and goes to its destination, it will be empty in return. The follow graph shows how many freight vehicles enter and leave the market full and empty. In freight vehicle driver's survey, about 25% driver said that some time they return with the goods.

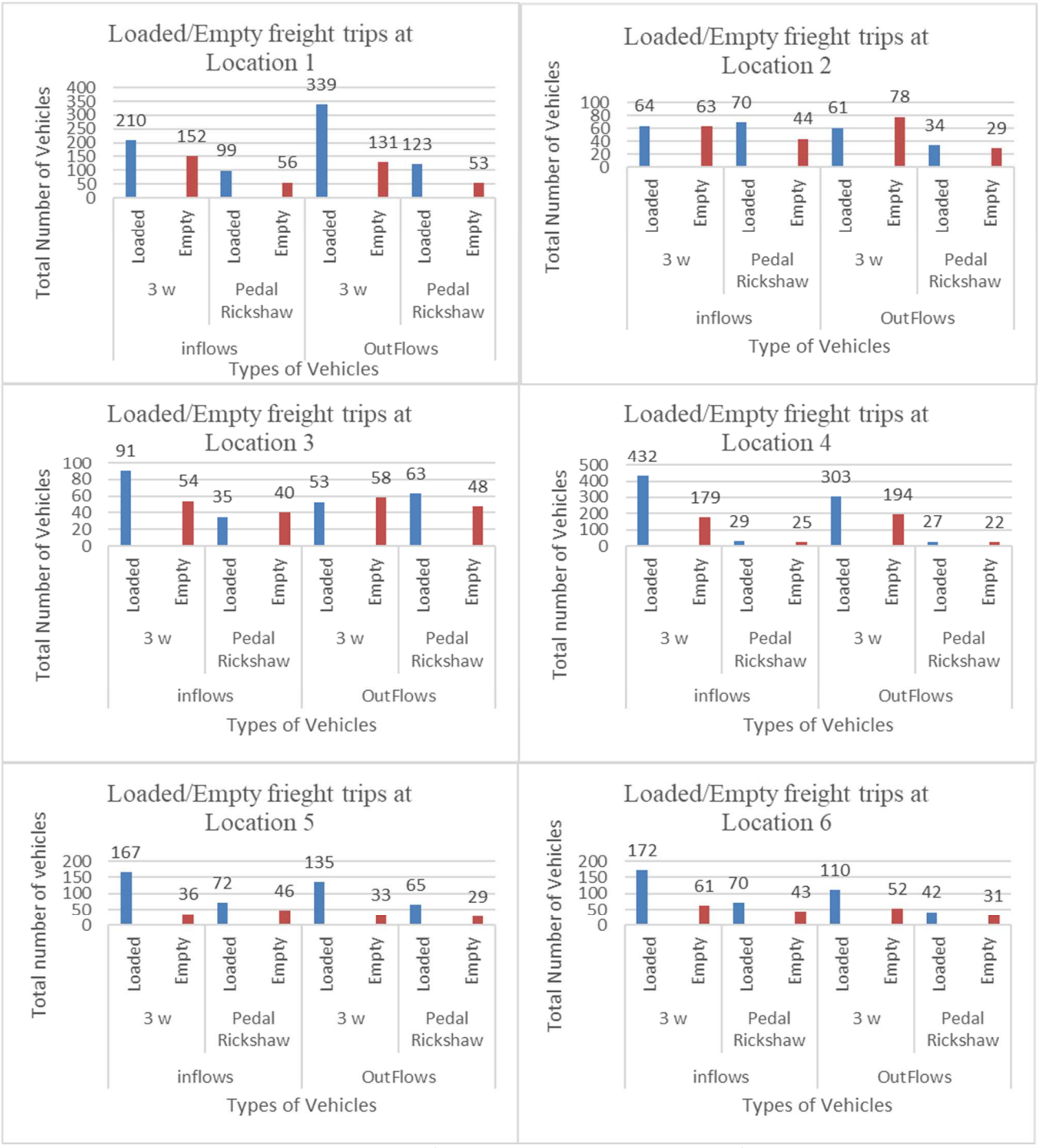


Figure 8 Loaded and empty freight vehicles incoming and outgoing from market

From the Figure 8, it is seen that almost an equal number of empty trips are generated and attracted from the market as compared to loaded trips. This means that all the freight vehicles either come to the market to deliver the goods, or they go from the market to another

destination to deliver the goods. They will be empty when they return from the trip.

5.4 Parking condition in the market

The survey determines the types of vehicles that market owners and employees bring to the market. Most employees come in private 2-Wheeler vehicles, which is about 60% of the total employees. Another 23% of employees come to the market by bus (public transport), another 10% of employees come by walking and another 7% of employees come by rickshaw (Figure 9). Employees who come with a private vehicle park 69% of their vehicles in the basement parking lot and the remaining 31% park their vehicles in on-street parking (Figure 10). This vehicle stays in the park all day. The short-term use of on-street parking by visitors is not considered.

All the vehicles used for the transportation of goods in the market are hired vehicles, and about 73% of the transport is by 3-wheeler rickshaw, 21% by 3-wheeler pedal bicycle, and 6% by 2-Wheeler Scotty (Figure 11). About 54% of those vehicles are parked on the premises during loading/unloading and the remaining 46% are parked on the street (Figure 12). Freight vehicles or other vehicles that use on-street parking They cover both sides of the road and reduce the width of the road. which causes traffic problems.

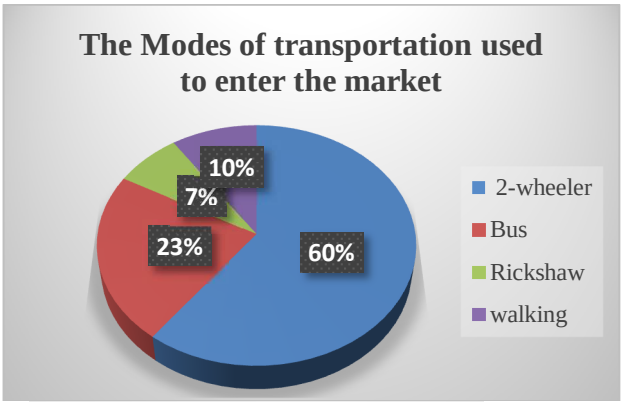


Figure 9 Vehicles used by employees to enter the Gheekanta market

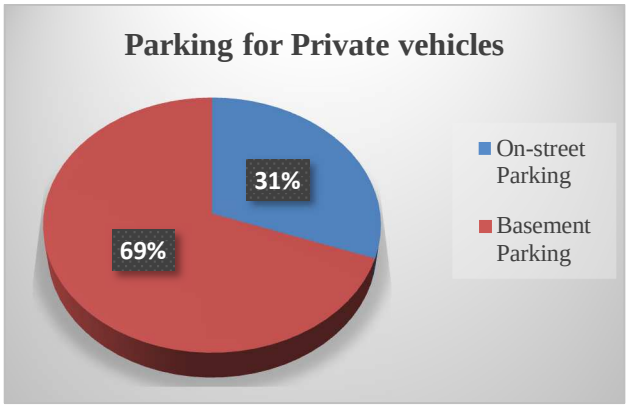


Figure 10 Parking of private vehicles in the market

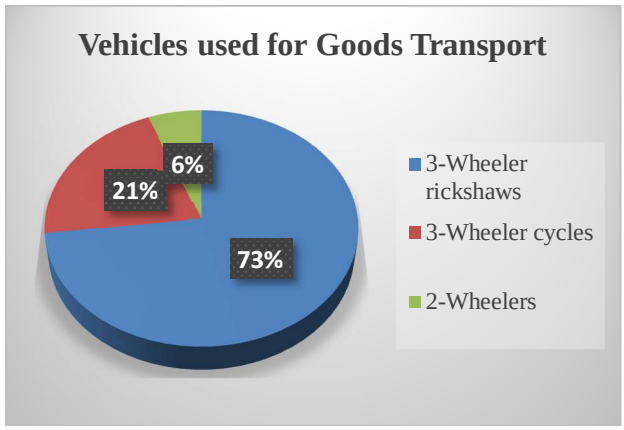


Figure 11 Vehicles used for goods transportation in market

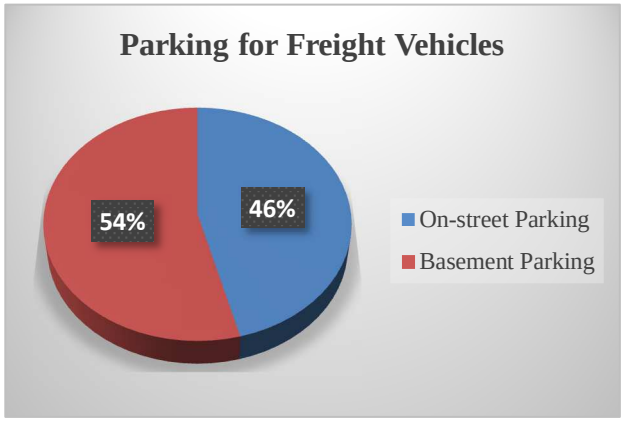


Figure 12 Parking facilities for goods vehicles in the market

6 Conclusion and way forward

For the economic development of any city, freight transportation is as important as passenger transportation. because it serves necessary commodities and helps in the production. But when freight transport comes into contact with urban areas, it creates negative impacts such as congestion on urban roads, extra noise and air pollution, etc. This study was carried out at Gheekanta wholesale market, Ahmedabad. Two models were developed in this study to estimate the number of trips produced and attracted by market. The freight trip attraction model has an R Square of 0.704. In this model, the number of trips attracted by shops depends on the quantity of incoming goods in the shop, the average floor area of the shop, and the distance between the transport offices to the Gheekanta market. The number of trips is increasing as the quantity of goods and the floor area of the shops increase. And trips decrease with increasing distance. The FTA model has significance F value and P-value in the statistical parameters are less than the critical value (0.05). That means a model can significantly predict the number of trips attracted by shops. The freight trip production model has an R Square of 0.715. The number of trips products by shops depends on the number of employees working in the shop and the distance between the market and the transport

office. The number of trips increases as the number of employees increases, and trips decrease as the distance increases. The FTP model has significance F value, and P-2values a'e less than the critical value (0.05). It means a model can significantly predict the number of trips produced by shops. In this market, the road that connects locations 1 and 4 is the main road of the market. on which a large number of vehicles are seen. Traffic congestion occurs frequently on this road. To reduce congestion, the main road of the market needs to be converted into a one-way street. It will reduce the congestion problem in the market and also increase the speed of vehicles, reducing travel time. The vehicles coming from other directions will travel from outside the market. The length of the main road is 1 km and the length of the road outside the market is 1.7 km, so the drivers will have to travel an extra 0.7 km. But it can give more benefits to the driver as there is extra fuel consumption and time delays due to congestion in the market. The market produces and attracts an equal number of loaded and empty freight vehicle trips, which causes extra load on the roads and congestion. For that, an online system needs to be developed in which drivers of freight vehicles are registered and goods are allotted to them by the system. This will reduce the number of unnecessary trips by empty freight vehicles. The market does not have parking available for about 31% of the private vehicles used by the shop owners and workers and 46% of freight vehicles. They parked their vehicles on the street, which encroaches on the road width and creates traffic problems. The market needs faster methods of loading and unloading, such as elevators, which transport goods faster than laborers in the complex. This has resulted in reduced parking time for freight vehicles during loading and unloading. The market attracts 31018 PCU/day trips in one day and produces 34038 PCU/day trips. which causes air pollution in the market. To reduce air pollution, eco-friendly freight vehicles like EV rickshaws should be used in the market. The study focuses mainly on the Gheekanta market in Ahmedabad. The study takes into account the trips between the market and the transport offices within Ahmedabad. The impact of freight traffic on market traffic is being considered. The impact on overall city traffic outside the market has not been taken into account. which can be considered as a future study. The model generated in the study can be used for planning of similar types of markets.

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