Development and Evaluation of Freight Consolidation Strategies

Authors

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Centre of Excellence in Urban Transport

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Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the areas of clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance.

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ABSTRACT

The objective of the study is to identify a suitable freight consolidation strategy and assess its feasibility for a freight trip generation hub in Chennai as a case study. We reviewed the literature to gather the best practices around the globe and conducted a reconnaissance survey on possible study areas. We selected the Ambattur Industrial Estate (AIE) as a study area given its proximity to the city centre and diversity in the establishments. A questionnaire was developed based on learning from the literature review as well as a pilot survey.

Face-to-face interviews with establishment owners and managers provided characteristics of the industries, freight trip characteristics, current consolidation practices (if any), and their willingness to participate in a future consolidation plan. Ten percent of the establishments in AIE were randomly selected and surveyed to obtain a representative sample. Analysis of the survey data revealed details about the number of intra-estate trips (O-D within AIE) and their quantities. Similar details about inter-estate trips (between AIE and other industrial estates) were also gathered.

We developed a feasible consolidation strategy by taking into account the concerns raised by establishment owners, understanding their current practices, and willingness to participate in a future consolidation plan. We propose a mix of physical consolidation centre and in-vehicle consolidation.

Finally, we developed mobile apps to enable establishment owners, truck drivers, and consolidation manager to be part of the developed strategy. Our analysis shows that the proposed policy will result in lesser freight vehicle kilometres travelled and reduce tailpipe emissions.

CHAPTER 1. INTRODUCTION

Urban freight transport is the movement of freight vehicles into, out of and within an urban area. The urban freight system includes manufacturing facilities, seaports, airports, distribution centres, wholesale and retail establishments, restaurants, and end customers connected by a network of railroads, roadways, waterways and pipelines for the movement of goods. Last-mile delivery of goods predominantly occurs by roadways involving manufacturers' warehouses, third-party logistics provider, wholesale and retail stores and end customers at home and offices as major participants.

The freight industry has a very complex and disintegrated system with urban freight traffic increasing day by day to meet the growing needs of an increasingly urban population. Though this is a result of economic growth, there are consequences due to the inefficiency in transportation. The large-scale industries, distribution centres and third-party logistics operators have well-defined supply chain logistics plans to tackle traffic congestion. However, the smaller establishments, such as the independent wholesale and retail outlets, generate substantial freight traffic and their disaggregate operations are comparatively less amenable to city-wide plans to reduce traffic congestion.

About [1]10 - 15% of the road traffic is contributed by freight vehicles, and most of the freight trips carry less than truckload (LTL), i.e. underutilised in terms of truck capacity. LTL and empty trips are likely to be more when the carrier takes care of incoming or outgoing trips only. This results in an increase in the [2]number of trucks using the roads and consequently increasing congestion and emission generated by fuel combustion (Schulte et al., 2015). Recent empirical studies on urban freight vehicles show an average load factor of only 30–40%[3] and more than 20% of vehicles drive empty[4]. Freight cost can be minimised considerably by clubbing or pooling the goods from nearby or neighbouring suppliers or clients to form truckload prior to transportation.

Freight consolidation is the process of combining multiple packages or partial loads together into one truck. Freight consolidation has monetary and environmental benefits for both customers (industries/establishments) and truckers. Freight consolidation should be considered by

[1] BESTUFS, 2006. Quantification of Urban Freight Transport Effects I.

[2] F. Schulte, R.G. González, S. Voß, Reducing port-related truck emissions: coordinated truck appointments to reduce empty truck trips, Computational Logistics, Springer (2015), pp. 495-509.

[3] R. Bozzo, A. Conca, F. Marangon, Decision Support System for City Logistics: literature Review, and Guidelines for an Ex-ante model

[4] M. Tozzi, M.V. Corazza, A. Musso, Urban goods movements in a sensitive context: the case of Parma Res Transp Bus Manag, 11 (2014), pp. 134-141, 10.1016/j.rtbm.2014.03.003

stakeholders of the freight industry to avoid/minimise LTL freight vehicles in urban areas which , in turn, reduces the road traffic and emission of greenhouse gases.

1.1 Concept of urban consolidation centre

An urban consolidation centre (UCC) is a logistics facility that is situated in the urban area or nearby to perform freight consolidation. The UCC operator sorts and consolidates part loads and makes deliveries to the final destinations utilising the space of truck completely.

UCCs came as a reaction to concerns towards environmental impacts. UCCs can reduce heavy goods vehicles operating in urban areas, reduce congestion and emissions, and improve delivery reliability.

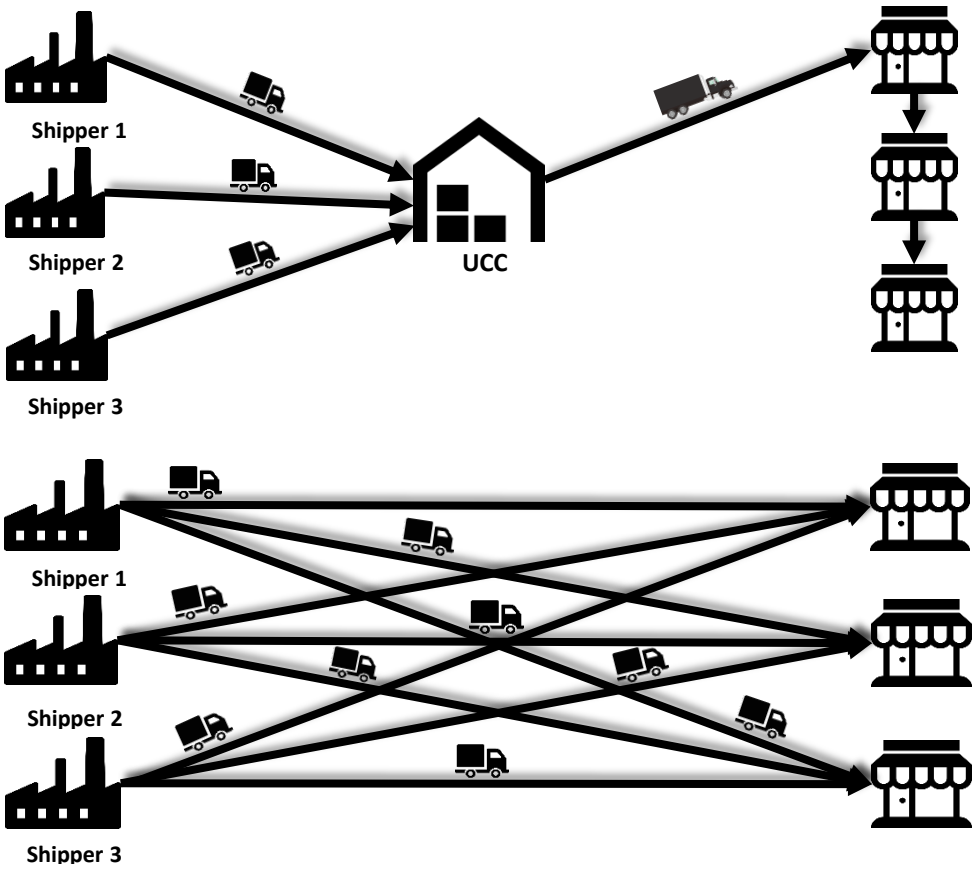


Figure 1: Freight movement with and without UCC

1.1.1 Benefits of UCCs

UCC helps in reducing the total distance travelled. Fewer goods vehicle kilometres are also associated with reductions in conflicts between goods vehicles and other road users, and greater pedestrian safety. It also results in lesser pollution.

There has been a substantial reduction in CO2 emissions (25%) even though internal combustion engine vehicles were used and a 38% reduction in traffic congestion (Patier, 2005).

1.1.2 Difficulties/Barriers

The main difficulties are: ensuring participation of all stakeholders, ensuring wide-spread participation, and reducing the financial costs of operations.

Another main issue regarding UCCs is that consolidation will lead to an increment in expenditure to the delivery operation as a result of double handling (McKinnon, 1998a). Therefore, it is critical to discuss the implication of such schemes with potential customers and by demonstrating that UCCs will help in the reduction of cost in other parts of operations.

1.2 Case Studies of UCC in different countries

Urban consolidation centres implemented and tested in various countries are listed in the tables below. Basic information of UCC, its benefits and drawbacks of case studies considered for literature review are discussed briefly.

Table 1: Case study of UCC in Barcelona, Paris and Copenhagen

Case Study/ Literature Title	**Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case**	**La Petite Reine : Home deliveries using Cargocycles® and electric vans in Paris**	**Rethinking Deliveries Report- TFL**
Country/City	Cities of Barcelona and Valencia	France/Paris	Copenhagen

Case Study/ Literature Title	**Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case**	**La Petite Reine : Home deliveries using Cargocycles® and electric vans in Paris**	**Rethinking Deliveries Report- TFL**
Subsidized/ Partnership		No/Local authority support in implementing at ground level	40% subsidised by Copenhagen local authority
Location (UCC)	Micro-platform, at the edge of the access belt of the historical centre of Valencia	Outskirts of the market area	Outside the city
Target Area Type/Group		Multiple retailers	Retailers in the city
Type of Freight Vehicle Used	Electric tricycles	Electric tricycle and electric van	Peugeot partner van, 3.5-tonne modec truck
Types of Commodities Handled	Parcel services and similar shipments (i.e. fashion shops)	FMCG (both non-food and food)	Non-food pallets
UCC Achievements		Emissions & congestion by delivery vehicles minimised	40-45 % reduction in freight vehicles and 10% reduction in pollutant emissions

Case Study/ Literature Title	**Designing new models for energy efficiency in urban freight transport for smart cities and its application to the Spanish case**	**La Petite Reine : Home deliveries using Cargocycles® and electric vans in Paris**	**Rethinking Deliveries Report- TFL**
UCC Failures/ Drawbacks/Limitations	1. Manager of the transshipment terminal should be a neutral company that does not compete with the other operators. 2. Support of the city council is crucial to obtain positive feedback. 3. Location of the transshipment terminal was not appropriate	1. Does not qualify for a full-fledged UCC 2. Limited to a few retailers and service area	

Table 2: Case study of UCC for retailers - Japan, Italy and Spain

Case Study / Literature Title	**Urban Distribution Centers: A means to reducing freight vehicle miles traveled**	**Developing urban logistics spaces: UCC and PLS in South-Western Europe**	**Developing urban logistics spaces: UCC and PLS in South-Western Europe**
Country/City	Japan, Tenjin	Italy, Vicenza	Malaga, Spain
Subsidized/ Partnership	No	Govt. - Pvt. Partnership	Yes
Location (UCC)	7.5 km from CBD	Out of city limits	1st floor of multi-level car parking building
Target Area Type/Group	Retailers in CBD	Retailers/ FMCG	Retail

Case Study / Literature Title	**Urban Distribution Centers: A means to reducing freight vehicle miles traveled**	**Developing urban logistics spaces: UCC and PLS in South-Western Europe**	**Developing urban logistics spaces: UCC and PLS in South-Western Europe**
Type of Freight Vehicle Used	Trucks	Electric vehicles	EV
Types of Commodities Handled		Food, clothing, beverages	Food, clothing
UCC Achievements	Delivery vehicle requirement down by 61% and 6.8% reduction in parking time	On time delivery of goods achieved as EV's entry is not restricted	On time delivery of goods to a restricted area by use of EVs
UCC Failures/ Drawbacks/Limitations	Limited no. of participants as not compulsory		Only 1/3rd of total retailers are participating

Table 3: Case study of UCC for retailers in New York, Korea and Netherlands

Case Study / Literature Title	**Topps Partners with KANE for Efficient National Distribution**	**Demand determinants for urban freight consolidation centre-A case of Korea**	**New challenges for urban consolidation centres: A case study in The Hague**
Country/City	Brooklyn, NY	Korea	The municipality of Hague, Netherlands
Subsidised/Partnership	No	Yes	Yes

Case Study / Literature Title	**Topps Partners with KANE for Efficient National Distribution**	**Demand determinants for urban freight consolidation centre-A case of Korea**	**New challenges for urban consolidation centres: A case study in The Hague**
Location(UCC)		Border of the service area	Binckhorst business area
Target Area Type/Group	Distribution centres, including outbound freight to Topps customers nationally – from Walmart to small corner stores.	Retailers in that City centre	531 shops in the city centre of the Hague
Type of Freight Vehicle Used		Small and medium capacity vehicles	Light or medium electric trucks (Range of 40km or 30km) at normal speed 50kmph
Types of Commodities Handled	Entertainment products, principally collectible trading cards and candy	Food and beverages	Fashion, living, electrics, entertainment, books and other retail, all self-employed businesses with less than 1000 m^2 sales surfaces
UCC Achievements	1.Reduced freight costs 2.20% lead time improvement 3. Lower handling rates using shared labor pool 4.Reduced carbon footprint	Reduce vehicle km, time vehicle spent on the road, no. of stops, peak time operations	Vehicle kilometer reduction.

Case Study / Literature Title	**Topps Partners with KANE for Efficient National Distribution**	**Demand determinants for urban freight consolidation centre-A case of Korea**	**New challenges for urban consolidation centres: A case study in The Hague**
	through fewer truck miles		
UCC Failures/ Drawbacks/Limitations		Incorrect estimation of demand, neither all transport companies nor all freight are suitable for UCC	

CHAPTER 2. FREIGHT CONSOLIDATION STRATEGIES

2.1 Need for the study and its outcome

Urban freight distribution involves a complex supply chain/logistics system operating under a severely constrained and complex environment. As goods move from the manufacturers to the consumers through the hands of multiple agents, the level of fragmentation increases. This unorganised and inefficient movement of goods increases the number of freight trips, congestion and associated emissions. Currently, numerous parcel services operate to meet growing freight transport demand, but they employ inefficient methods and do not cater to short-distance and urgent deliveries. Often industries require urgent deliveries which makes them employ (rent/lease) freight vehicles to carry their goods which in most cases will be less than truckload and costs more.

The purpose of the project was to work on a consolidation strategy based on the extant freight transport industry, freight volume produced or generated, freight type, current freight fleet composition, and geographical distribution. The consolidation strategy was developed to aggregate and distribute various goods within the city, thereby minimising their trip distance and number of freight vehicles required. The study estimates the emission reductions and cost benefits for various stakeholders participating in consolidation. A road map for the implementation of consolidation strategy using app-based bookings was developed.

2.2 Approach and methodology

The following steps were adopted in this study.

i. Selecting a study area: The study area was identified through field-visits to locations within Chennai where considerable freight trips were happening. The study area was finalised with the help of experts in Madras Chamber of Commerce and Industry (MCCI).

ii. Analysis of freight movement: The nature of freight movement taking place within that area, freight vehicles used for deliveries, factors affecting their choice of vehicle and transporter, the time of deliveries and sensitivity to the cost of transportation were analysed.

iii. Determining the scope for consolidation: Consumers' attitude and preference towards the concept of consolidation was determined. Potential destinations and the scope for

consolidation were estimated. A heterogeneous mix of freight vehicles that will aid in consolidation was also identified.

iv. Analysing benefit-cost: Cost for operating a UCC based on the data collected was estimated (see chapter 3.) For a successful UCC, all the stakeholders involved in consolidation should profit, and it must be self-sustaining.

v. Developing a mobile application: A mobile application for consolidation was designed and developed. The app is a user-friendly mobile application for consolidating goods to meet the requirements of establishments, and to transport the commodities with a consolidation manager serving as an intermediary (see Chapter 4 for details).

2.3 Background of the Study area – Ambattur

Ambattur Industrial Estate (AIE) was chosen as our study area to understand the freight movement, develop freight consolidation strategy, and study the feasibility of establishing a consolidation centre. AIE is spread over an area of 1430 acres, consisting of approximately 1500 small and medium enterprises registered with Ambattur Industrial Estate Manufacturers' Association (AIEMA). Majority of the industries located in AIE are manufacturers of automobile components, engineering components, garments and pharmaceutical products. It is the biggest small-scale industrial estate in South Asia. AIEMA was started in the year 1963 to represent the interest of industrial units of Ambattur Industrial Estate. Meetings were held with the logistics committee of the Madras Chamber of Commerce and Industry (MCCI), and they suggested AIE as a potential location for consolidation center. Subsequently, joint meetings with MCCI and AIEMA were held and together it was agreed on Ambattur Industrial Estate as the study area for the freight consolidation study. The extent and location of Ambattur Industrial Estate are shown in figure 2.

Figure 2: Map showing study area - AIE

2.4 Framing of questionnaire

A questionnaire was framed to gather information on freight trip patterns and freight details from establishments in AIE by conducting face-to-face surveys. The main objective of the questionnaire was to observe the responses and validate the scope for consolidation of freight catering to industries located in AIE premises. The questionnaire was customised to understand origin and destination of freight trips, the purpose of the trip, frequency of freight trips, goods involved, freight trip patterns based on trip distance and quantity of goods (multi-stop or a single stop), and supply chain decision on trips. Information of the prevailing consolidation practices, availability of parking space, and warehouse were also captured in the questionnaire.

2.5 Data collection

The establishments were selected randomly from the AIEMA directory provided by AIEMA, and few more were randomly selected by walking around the AIE premises. The chosen industries were contacted to get confirmation of participation in our study and collection of their freight movement data. A letter of support from AIEMA was presented to the respondent to prove the authenticity of the survey. Face-to-face surveys using the questionnaire was conducted by staff of IIT Madras. About 10% of the industries located in AIE were selected as our sample (sample size 159) for this survey. The data collected from the questionnaire survey are as follows:

- Type of Industry

- Class or category of industry, the total area of industry
- Warehouse/storage space details
- Freight vehicle information (freight vehicle ownership)
- Unloading mechanism, parking space availability
- To/from trip details (location, distance, approximate cost of transportation, quantity, packing type, number of trips, frequency)
- Current and future scope for consolidation centre

The data collected was reviewed and analysed to chart out a consolidation strategy and work on the feasibility of establishing a consolidation centre at AIE premises.

2.6 Data analysis and consolidation strategy

2.6.1 Preliminary analysis of the questionnaire data

2.6.1.1 Type of industries

About 159 samples were collected out of which 48 industries were manufacturers of engineering products, 41 were manufacturing automobile components, 6 were manufacturers of both automobile and engineering components, and 21 were concentrating on job work (refer figure 3).

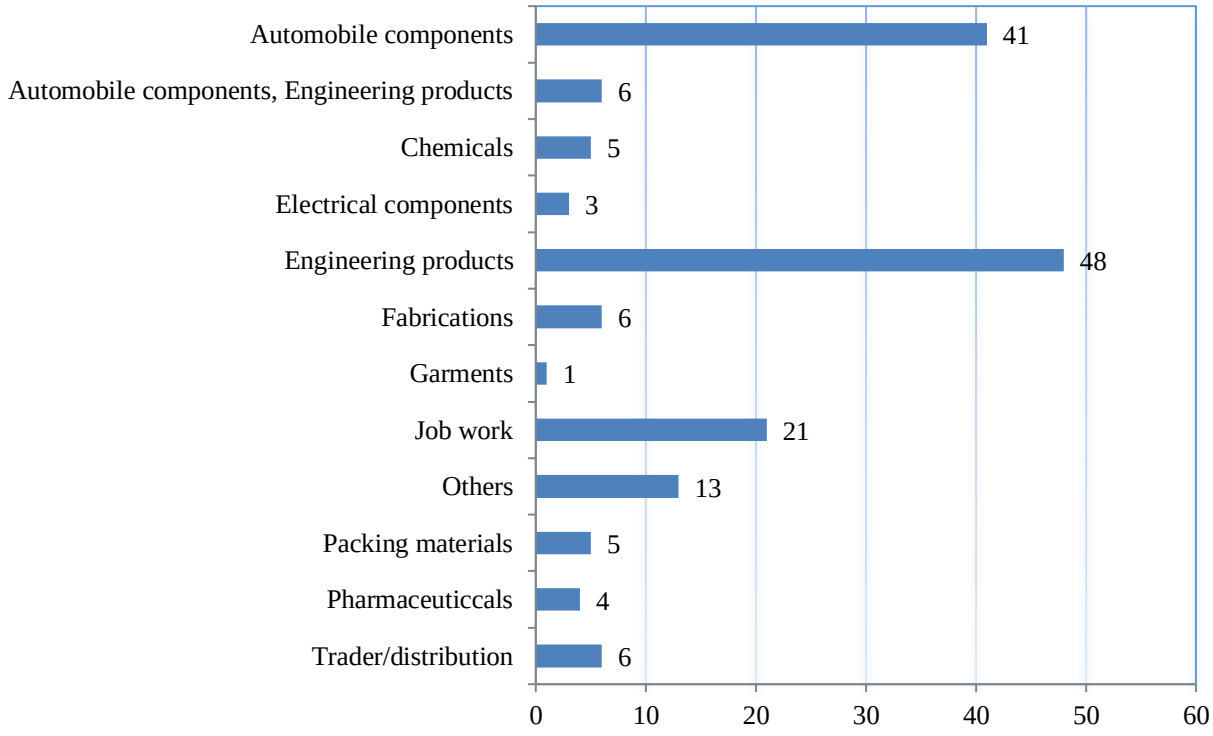


Figure 3: Distribution of type of industry from the sample

2.6.1.2 Class/category of industries

The industries were classified as micro, small, medium or large based on the investment and yearly turnover. As per our AIE sample, 66% of our sample were listed under small-scale industries, 19% under medium-scale industries and 12% under micro-scale (refer figure 4). The percentage of large-scale industries was comparatively small in the sample.

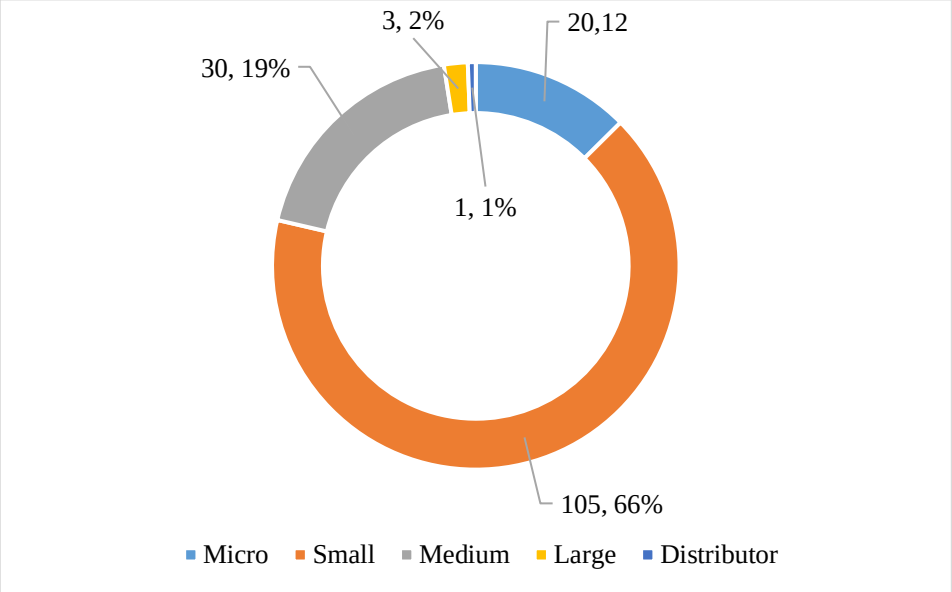


Figure 4: Distribution of industries in the sample based on category

2.6.1.3 Storage Space/warehouse availability

Storage space availability also plays a vital part in the number of trips generated/ produced by the industry. Unavailability of storage space results in just-in-time procurement/dispatch of the consignment, which will directly increase the number of trips from/to the industry. Whereas the industries with storage space can schedule less frequent trips since they can store inventory. Figure 5 shows the distribution based on storage space availability, 74% of the industries in the sample lacked storage space, and 26% had a warehouse. The location of the warehouse was collected from industries (26% of response) that had warehouse out of which 24% had their warehouse on site, and only 2% had their warehouse away from their industry.

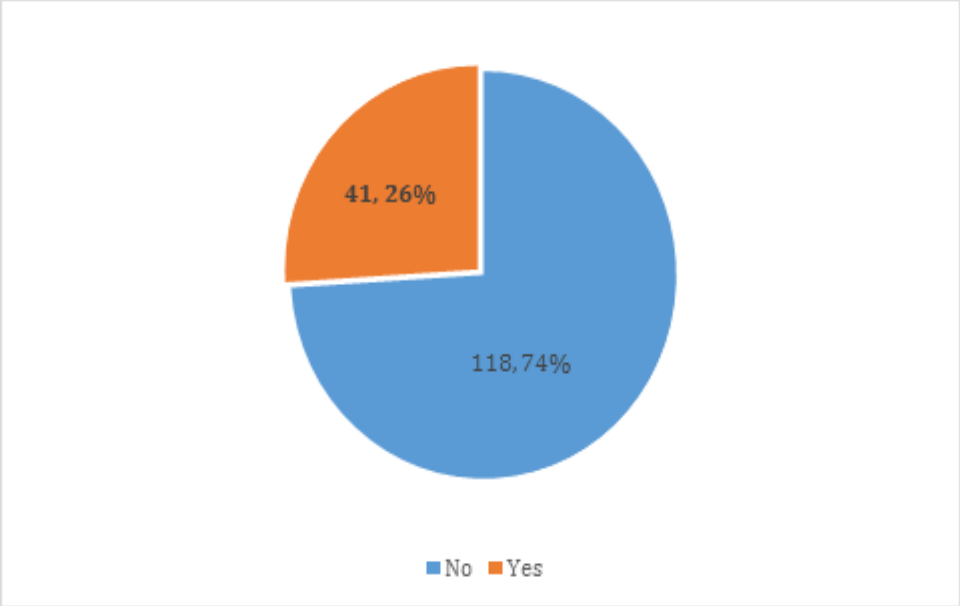


Figure 5: Availability of storage space/warehouse

2.6.1.4 Availability of parking space for loading/unloading

92% of the sample had ample parking space for freight vehicles for loading and unloading goods, and only 8% did not have sufficient space (refer figure 6).

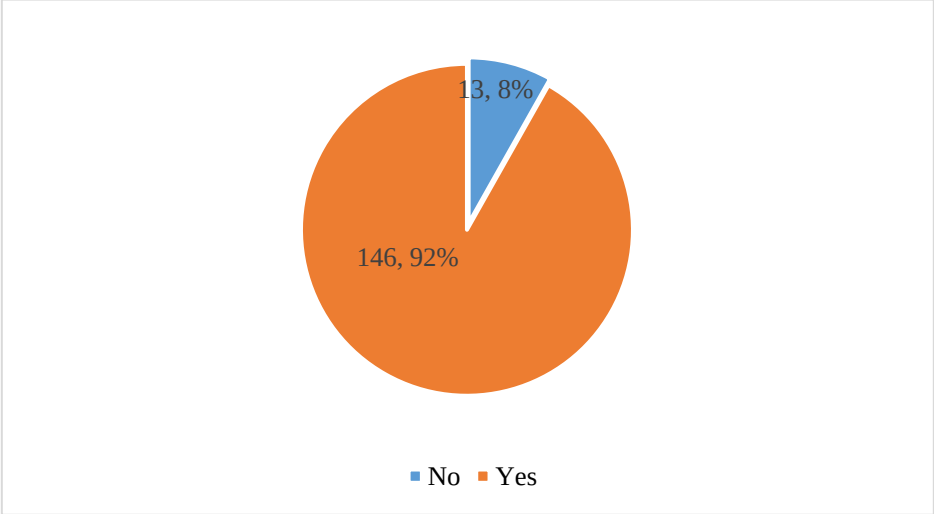


Figure 6: Availability of parking space for loading and unloading

2.6.1.5 Freight vehicle ownership

Freight vehicles commonly used in AIE are small pick-ups/vans, two-axle trucks, and large trucks. Majority of the sample (70%) do not own/lease any freight vehicles while 29% of the industries in the sample own freight vehicles (refer to figure 7). Most of the respondents preferred to hire

vehicles to cut down on the high expense incurred for the ownership and maintenance cost of their own or leased vehicle. Out of 29% of the sample who own freight vehicles, 22% own small pick-ups/vans, 6% owns two-axle trucks, and only one` industry owns large trucks.

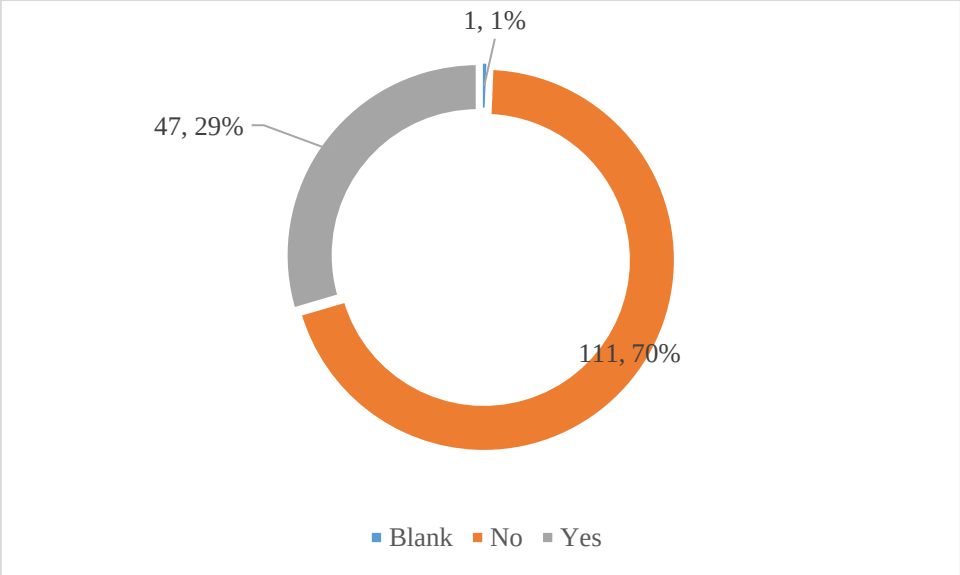
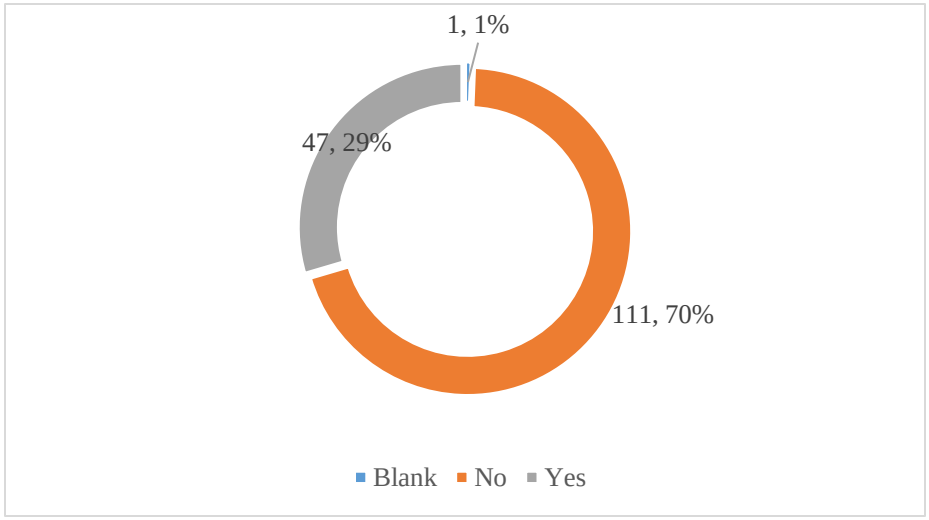


Figure 7: Ownership of freight vehicles

2.6.1.6 Using the same freight vehicle for receiving and delivering

Respondents were asked to comment on whether they used the same freight vehicle for receiving and delivering goods. 70% responded that they used a different vehicle for receiving and delivering (refer figure 8). The industries which own vehicles (small pick-up/van) most often use the same vehicle for trips within Chennai and rent vehicles for long-distance trips.

Figure 8: Usage of freight vehicle for receiving and delivering



2.6.1.7 Loading/unloading mechanism adopted by the industries

About 49% of the respondents manually load and unload the goods, whereas 22% of the respondents used mechanical equipment and 29% used either manual or mechanical methods depending on the weight and size of the material (figure 9).

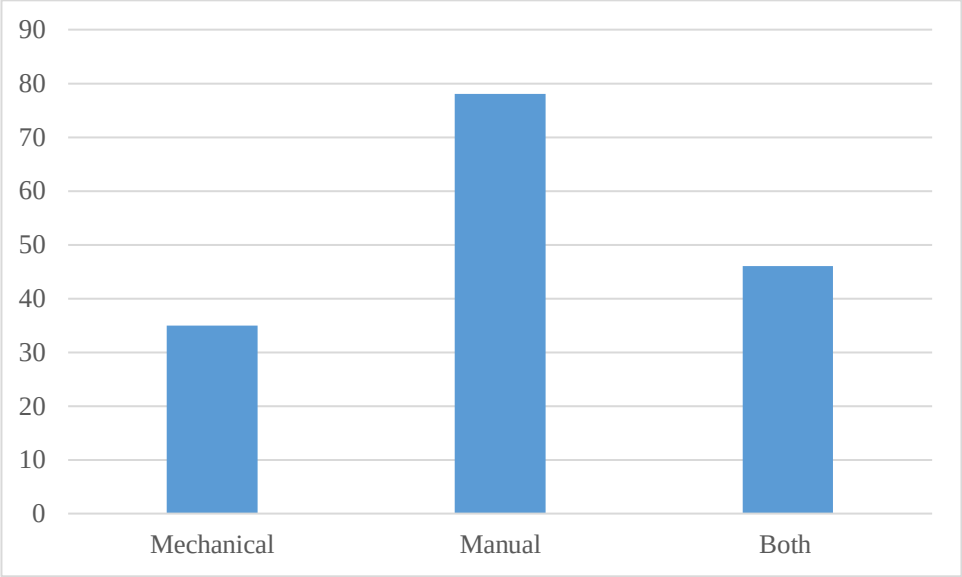
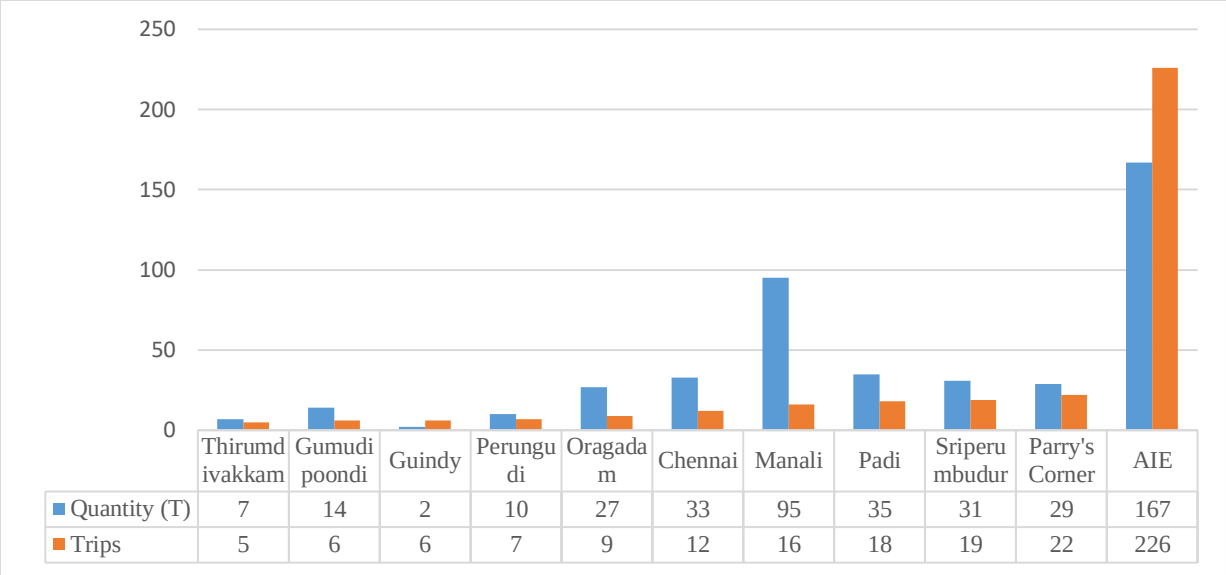


Figure 9: Type of loading and unloading mechanism adopted

2.6.1.8 Quantitative Analysis of trips made to/from Ambattur Industrial Estate

Survey questions were framed to collect data regarding the type and quantity of materials delivered to the industry, frequency of the trip, the cost of transportation, type of packaging involved, freight vehicle used, the location from where the goods come from, etc. Data were analysed separately for areas located within 50km radius of AIE and for those outside 50km radius of AIE to perform better analysis and understand the pattern (if any) of freight movement.

a) Daily trips to AIE from areas within 50km radius of AIE– Figure 10 represents the daily trips and tonnage received in AIE from areas located within Chennai. The weekly trips and monthly trips data observed in the questionnaire were converted to daily trips for the ease of this analysis. It is observed that daily trips within AIE is maximum (226 trips/day) and constitutes 66% of the total daily trips from within Chennai. We can infer that most of the trips are within AIE and are less than truck capacity.



	Thirumdivakkam	Gumudipoondi	Guindy	Perungudi	Oragadam	Chennai	Manali	Padi	Sriperumbudur	Parry's Corner	AIE
Quantity (T)	7	14	2	10	27	33	95	35	31	29	167
Trips	5	6	6	7	9	12	16	18	19	22	226

Figure 10: Daily trips and tonnage to AIE from within 50km radius of AIE

The spatial distribution of daily trips to AIE is shown in figure 11 and quantity of shipment in figure 12. The thickness of the line indicates the total number of daily freight trips from the location specified in the map to AIE, i.e. thicker the line, greater the number of trips. The highest number of daily trips to Ambattur Industrial Estate are from AIE itself, i.e. within AIE accounting for 226 trips per day, followed by Padi (18 trips), and Sriperumbudur (18 trips).

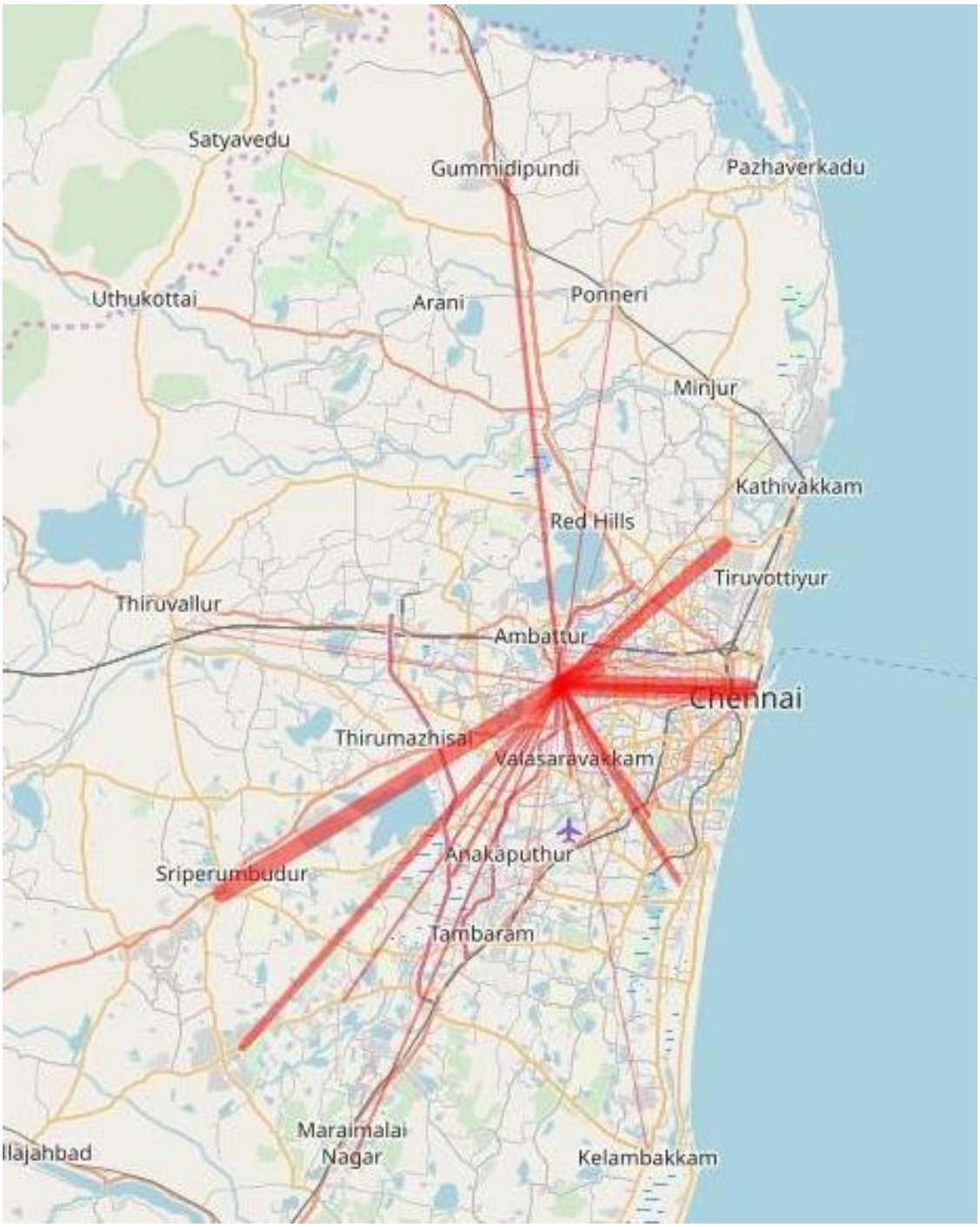


Figure 11: Spatial distribution of daily trips to AIE from locations within a 50km radius of AIE

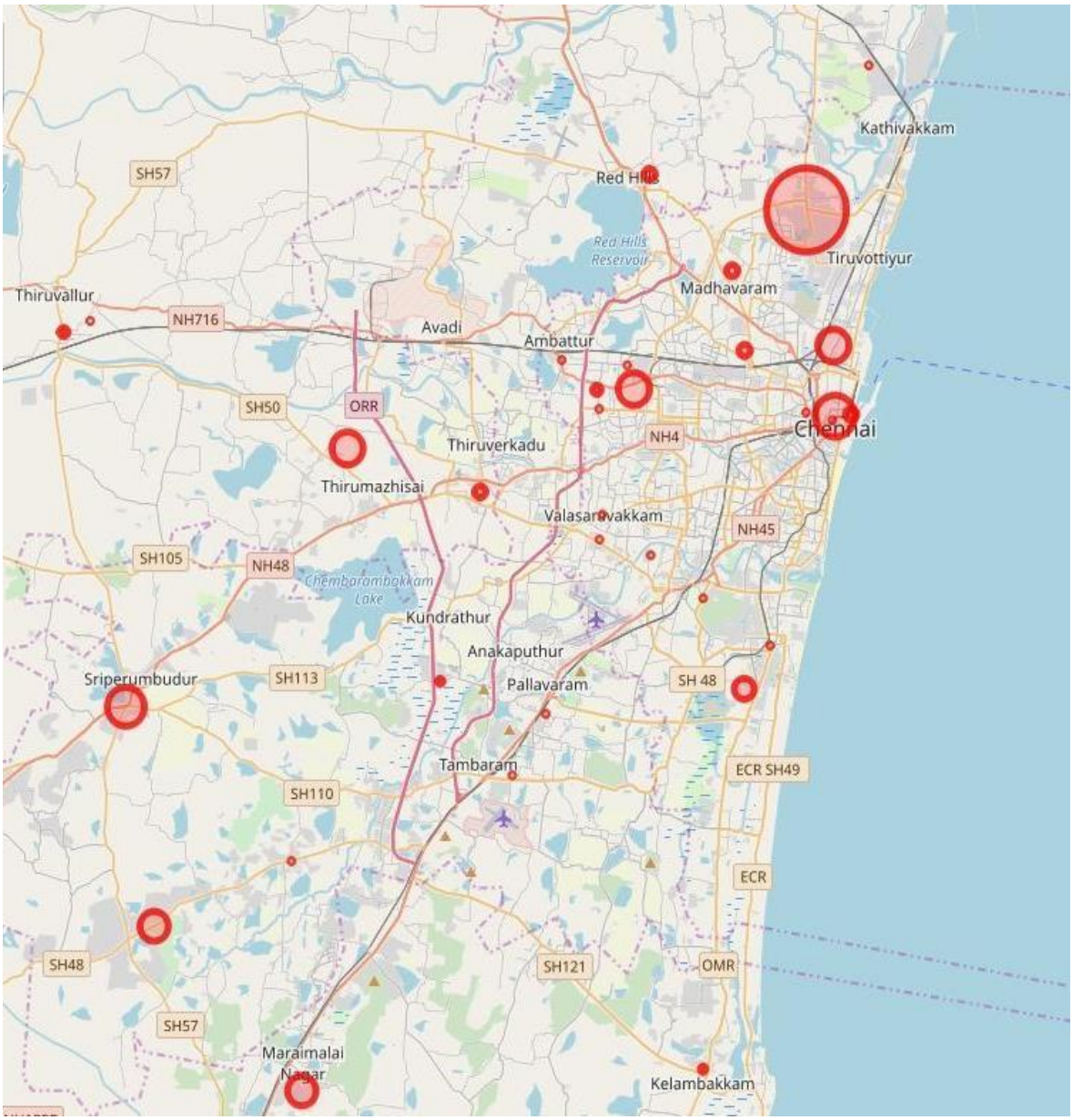


Figure 12: Spatial distribution of the quantity of shipments to AIE per day from locations outside a 50km radius of AIE

b) Daily trips from AIE to areas within a 50km radius of AIE

About 49% of the trips (figure 13) are within AIE accounting for only 24% of the quantity of daily shipment transported from within Chennai. This shows that trucks are underutilised in terms of truck capacity, and there is scope for consolidation of shipments to reduce the number of trips.

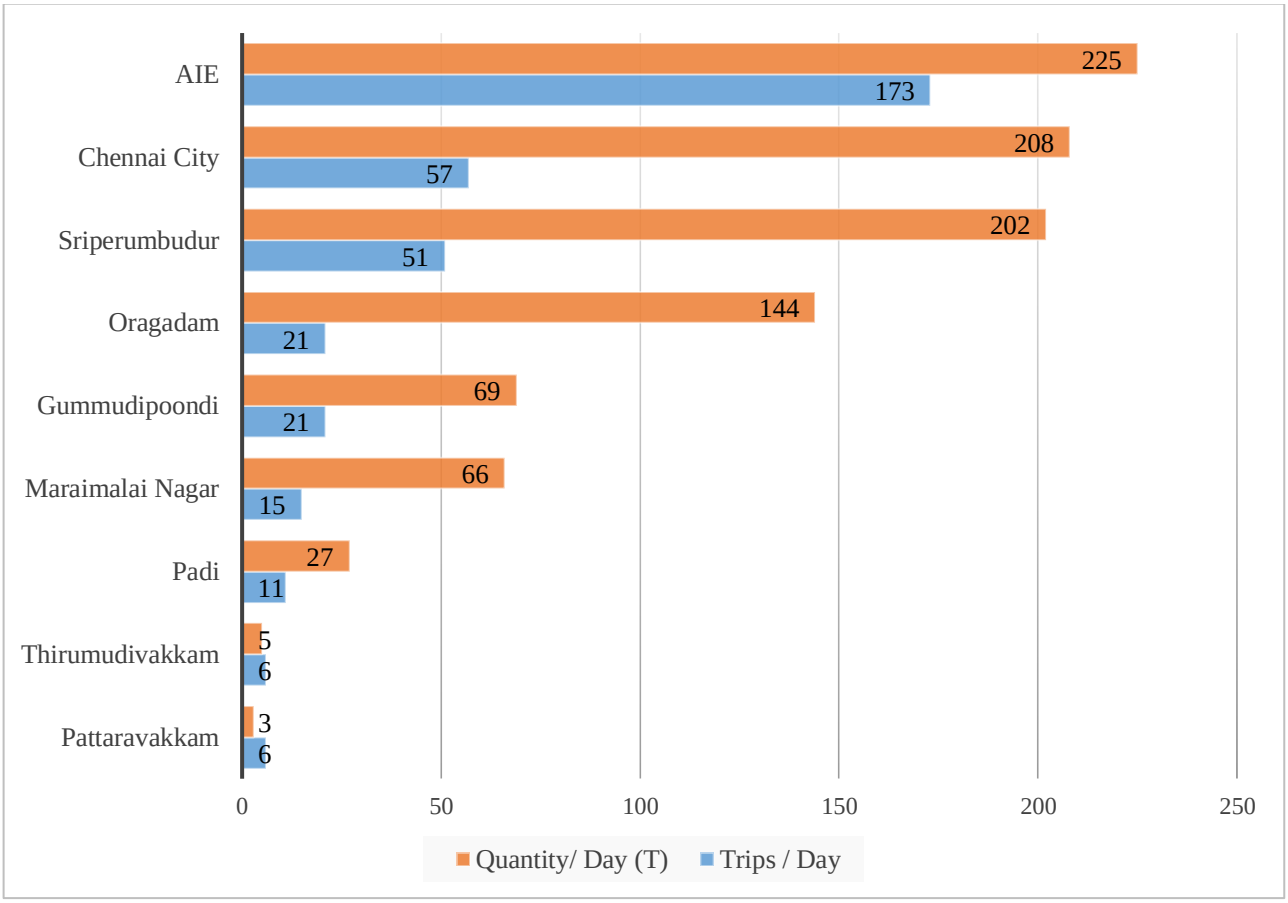


Figure 13: Daily trips and tonnage from AIE to within 50km radius of AIE

c) Daily trips and quantity to AIE from areas outside 50km radius of AIE

About eight trips (figure 14) and 64 tons are from Puducherry while three trips and 30 tons are transported from Gujarat. This shows that the quantity of shipment increases with the distance it is transported.

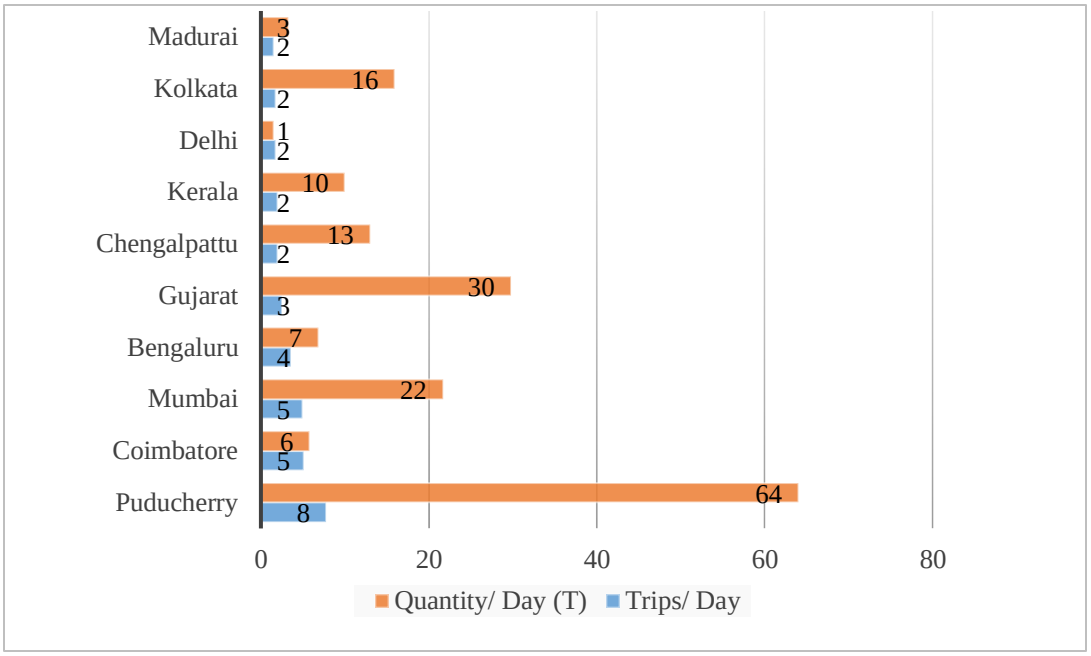


Figure 14: Daily trips and quantity to AIE from areas outside 50km radius of AIE

d) Daily trips and quantity from AIE to areas outside 50km radius of AIE

The chart below shows (figure 15) the maximum number of daily trips and quantity are transported to Trichy with an average payload of 7.5 tons per trip whereas an average of 1.2 tons per trip is transported to Puducherry.

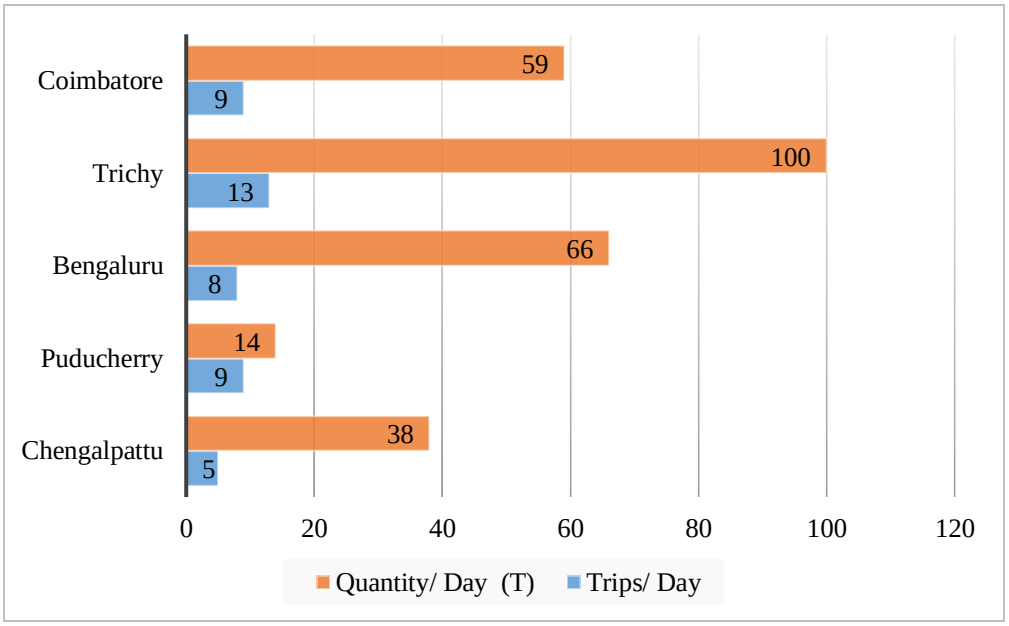
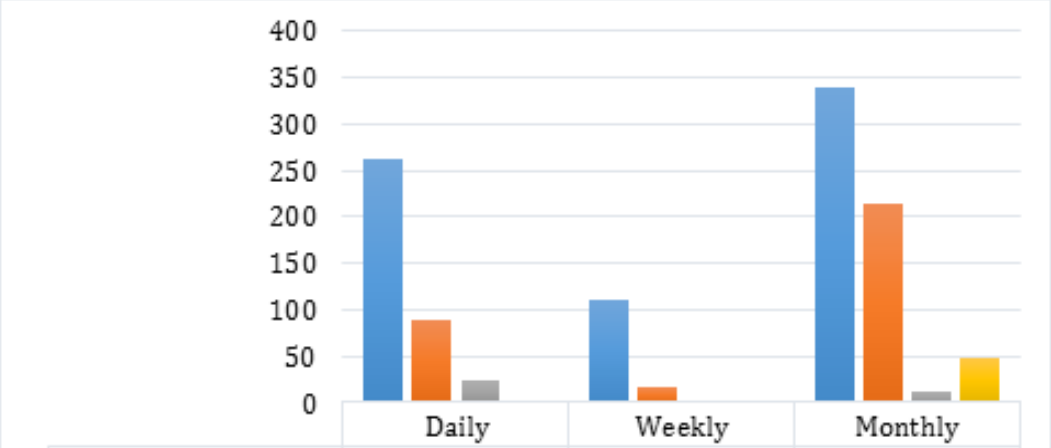


Figure 15: Daily trips and quantity from AIE to outside 50km radius of AIE

2.6.1.9 *Analysis of trips and quantity of shipment to/from AIE by vehicle type*

a. Number of trips from AIE to within 50km radius of AIE by vehicle type

The bar chart (figure 16) represents the total trips – daily, weekly and monthly generated from AIE to areas within Chennai by vehicle type. Analysis of the survey data revealed that 86% of the weekly trips and 70% of daily trips are made by small pick-ups/vans. Observation of the graph indicates that small trucks are predominantly used for freight transport irrespective of daily, weekly or monthly trips and two-axle trucks are preferred for monthly trips within Chennai.



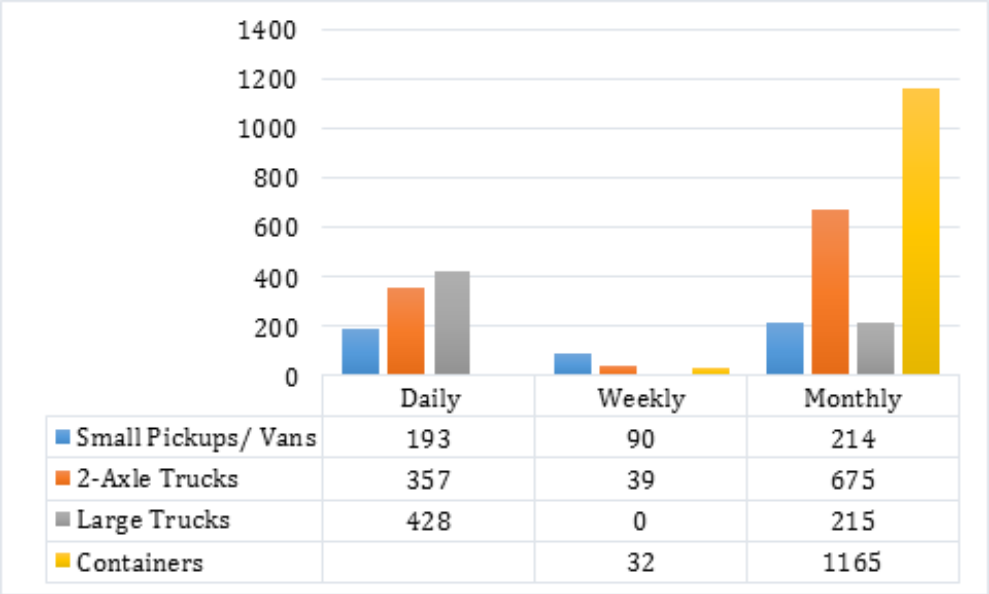
	Daily	Weekly	Monthly
Small Pickups/ Vans	263	111	338
2-Axle Trucks	89	17	214
Large Trucks	24	0	13
Containers		1	48

Figure 16: Total trips from AIE to within 50km radius of AIE by vehicle type

b. Quantity of shipment from AIE to within 50km radius of AIE by vehicle type

The distribution of the total quantity of shipment – daily, weekly and monthly by vehicle type is shown in the chart below (figure 17). 2-axle trucks and containers were effectively used in terms of payload carried on a trip. 36% and 29% of the daily and monthly payload from AIE to areas within Chennai are by 2-axle trucks. 51% of the monthly trips within Chennai are by containers which may be the finished product to automobile or other industries located within 50km of AIE.

Average quantity carried per trip by each vehicle type was calculated using the total quantity and total trips made. An average of 8.5 tons was transported by 2-axle trucks, whereas less than 1 ton (average) was transported by small pick-up/van.

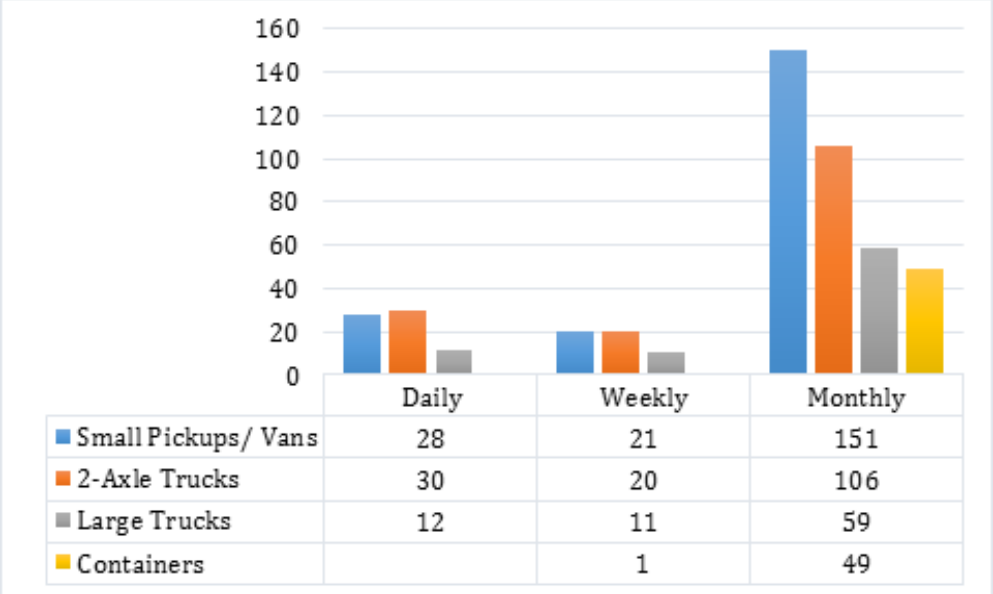


	Daily	Weekly	Monthly
Small Pickups/ Vans	193	90	214
2-Axle Trucks	357	39	675
Large Trucks	428	0	215
Containers		32	1165

Figure 17: Quantity of shipment from AIE to within 50km radius of AIE by vehicle type

c. Trips from AIE to outside 50km radius of AIE by vehicle type

In the case of trips generated from AIE to outside Chennai, survey data (figure 18) indicates that 2-axle trucks make the highest (44%) number of daily trips and small trucks account for 42% of the monthly trips. About 30 - 40% of weekly and daily trips are by 2-axle trucks, and 20% of the weekly trips are through large trucks. Small trucks make more trips on a daily, weekly, and monthly basis when compared with any other freight vehicle type.

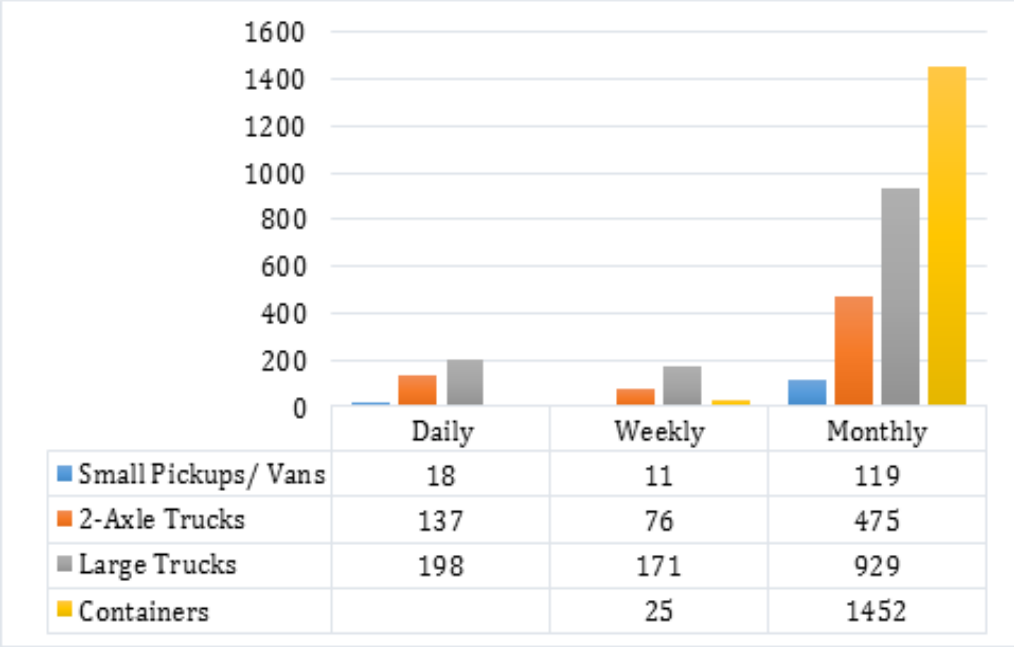


	Daily	Weekly	Monthly
Small Pickups/ Vans	28	21	151
2-Axle Trucks	30	20	106
Large Trucks	12	11	59
Containers		1	49

Figure 18: Trips from AIE to outside 50km radius of AIE by vehicle type

d. Quantity of shipment from AIE to outside 50km radius of AIE by vehicle type

In case of trips destined outside Chennai (figure 19), containers and large trucks carry more tonnage per trip made on a monthly and weekly basis.

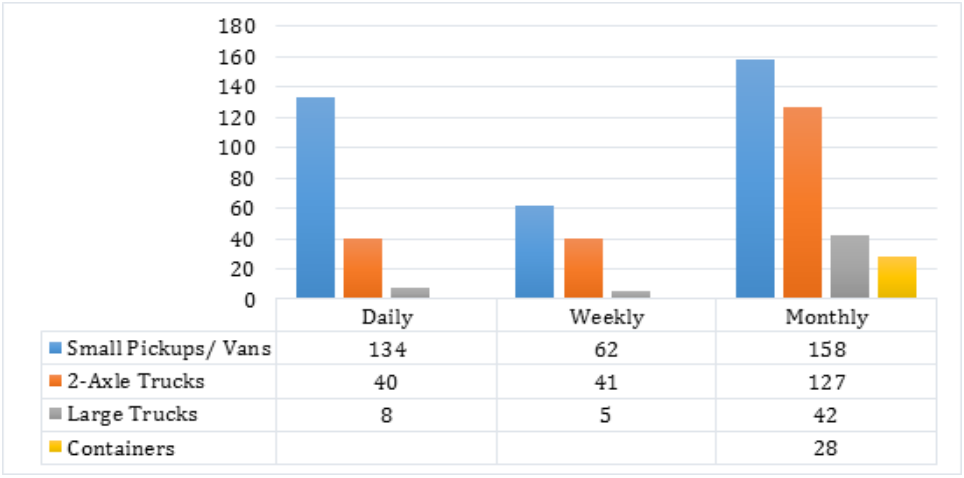


	Daily	Weekly	Monthly
Small Pickups/ Vans	18	11	119
2-Axle Trucks	137	76	475
Large Trucks	198	171	929
Containers		25	1452

Figure 19: Quantity of shipment from AIE to outside 50km radius of AIE

e. Number of trips to AIE to within 50km radius of AIE by vehicle type

Daily, weekly, and monthly trips within AIE is primarily (54%) by small trucks (figure 20). Data shows that small trucks and 2-axle trucks make almost the same number of trips within Chennai. Large trucks and containers together account for only 5% of the total daily, weekly and monthly trips.

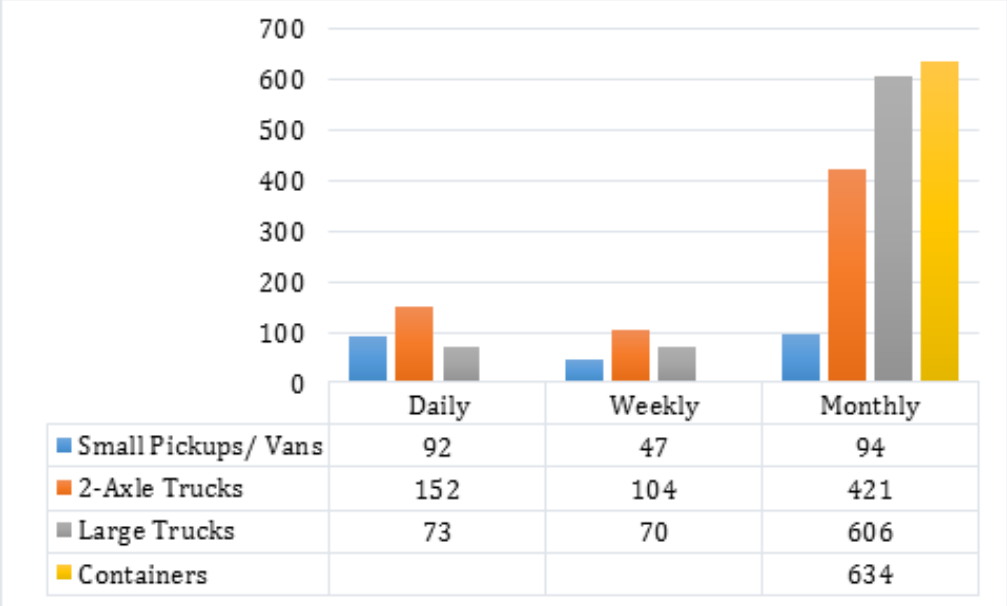


	Daily	Weekly	Monthly
Small Pickups/ Vans	134	62	158
2-Axle Trucks	40	41	127
Large Trucks	8	5	42
Containers			28

Figure 20: Total trips to AIE from within 50km radius of AIE by vehicle type

f. Quantity of shipment to AIE from within 50km radius of AIE by vehicle type

About 47% of the daily and weekly tonnage (figure 21) is transported by 2-axle trucks, and 41% of the daily trips in terms of tonnage is transported by 2-axle trucks. On observing the monthly trips made to AIE from within Chennai - 34% and 36% are transported by large trucks and containers respectively. Though small trucks make a maximum number of daily or weekly trips, the average quantity transported by small trucks seems to be less than 1 ton. This shows that small truck trips are underutilised and are predominantly used for just-in-time deliveries.

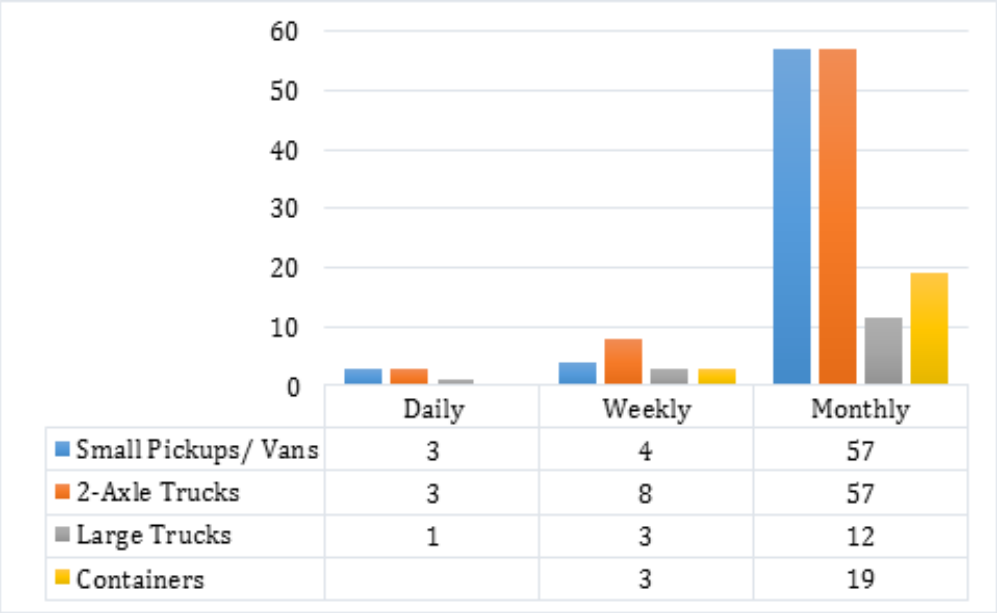


	Daily	Weekly	Monthly
Small Pickups/ Vans	92	47	94
2-Axle Trucks	152	104	421
Large Trucks	73	70	606
Containers			634

Figure 21: Quantity of shipment to AIE from within 50km radius of AIE

g. Number of trips to AIE from outside 50km radius of AIE by vehicle type

Small trucks and 2-axle trucks contribute about 42% each of the daily trips while only 15% of trips are by large trucks. Large trucks make the same number of daily and weekly trips. The number of trips attracted to AIE from outside Chennai is very less when compared with the number of trips produced from AIE to outside Chennai.

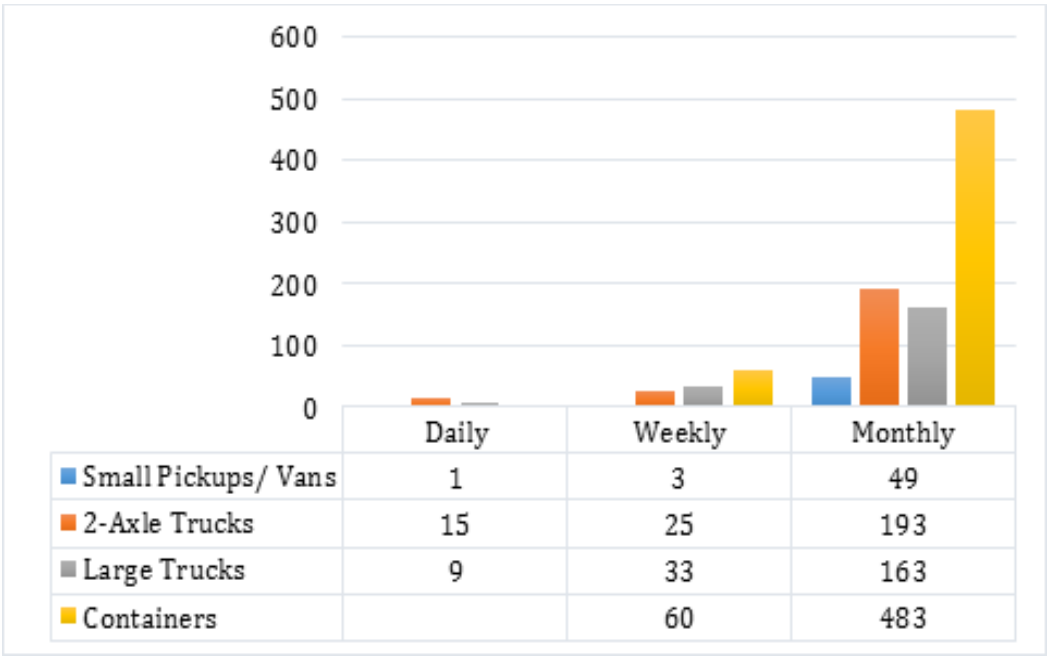


	Daily	Weekly	Monthly
Small Pickups/ Vans	3	4	57
2-Axle Trucks	3	8	57
Large Trucks	1	3	12
Containers		3	19

Figure 22: Total trips to AIE from outside 50km radius of AIE by vehicle type

h. Quantity of shipment to AIE from outside 50km radius of AIE by vehicle type

About 86% of the total quantity to AIE (figure 23) are from monthly trips out of which 47% is by containers, 18% by 2-axle and 16% by large trucks. This shows that containers and large trucks are preferred for long-distance shipment since it has more load-carrying capacity as compared with small trucks.



	Daily	Weekly	Monthly
Small Pickups/ Vans	1	3	49
2-Axle Trucks	15	25	193
Large Trucks	9	33	163
Containers		60	483

Figure 23: Quantity of shipment to AIE from outside 50km radius of AIE by vehicle type

2.6.1.10 Type of Packaging

Data regarding the type of packing, size/volume of the package, and weight of the shipment were collected. The response of this question can be used to understand the types of packaging for specific types of commodity and can be used for making consolidation decisions.

a) From AIE to within 50km radius of AIE

Data from the survey (figure 24) reveals that 33% of the goods are unpacked/loose, followed by 31% packed in boxes and 20% shipped in trays.

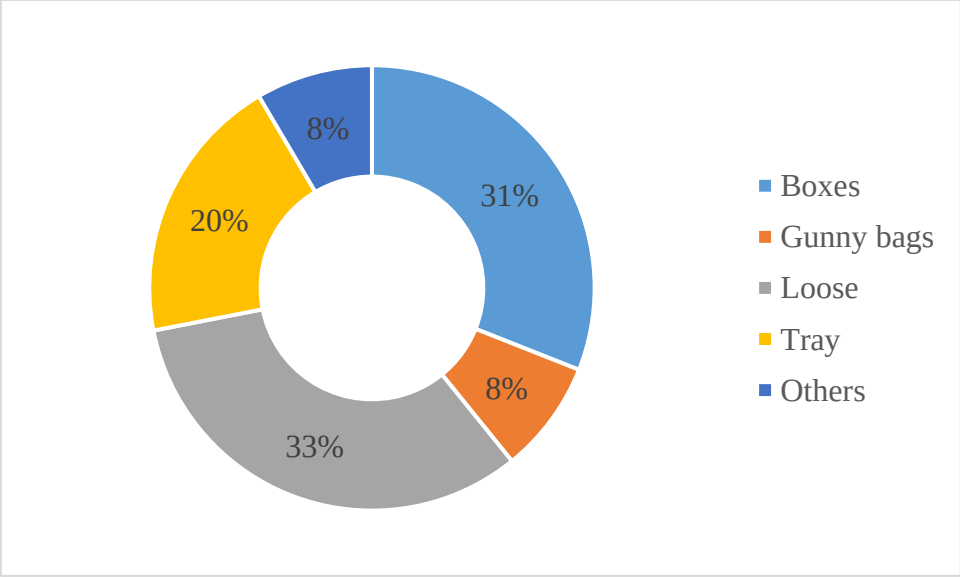


Figure 24: Type of packaging of goods from AIE to within 50km radius of AIE

b) From AIE to outside 50km radius of AIE

The chart (figure 25) shows that 48% of the goods are packed in boxes, followed by 27% being shipped loose.

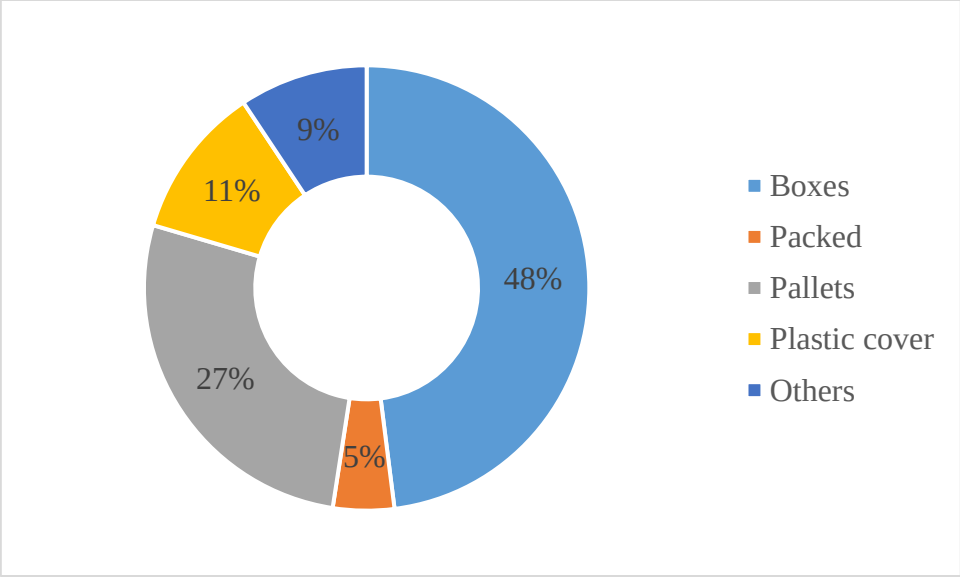


Figure 25: Type of packaging of goods to locations outside a 50km radius of AIE

2.6.1.11 Typical shipping time

a) From AIE to within 50km radius of AIE

Response regarding the time at which the goods are shipped to locations within Chennai (figure 26) shows that only 14% of the sample reported shipping goods throughout the day (24 hours) while the rest of industries limit to office hours. This shows that we can schedule the trips based on the time window specified by them and the consignment can be consolidated in order to reduce freight trips as well as the cost of shipping.

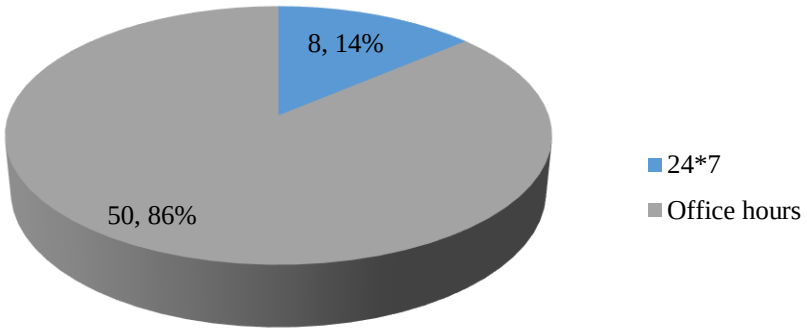


Figure 26: Preferred delivery time from AIE to within 50km radius of AIE

b) From AIE to outside 50km radius of AIE

To a question regarding the time at which the goods are shipped to locations outside a 50km radius of AIE, 88% of surveyed industries (figure 27) reported shipping goods during office hours and the remaining 12% ship their goods throughout the day (24 hours).

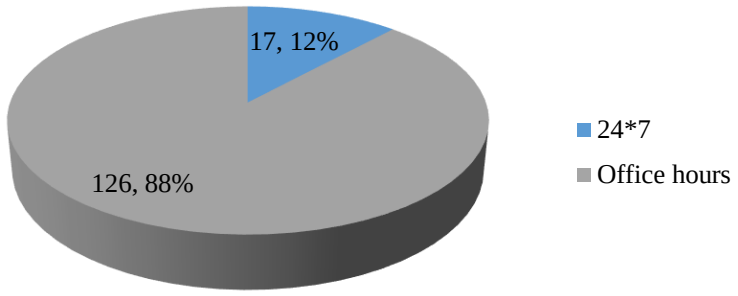


Figure 27: Preferred delivery time from AIE to outside 50km radius of AIE

2.6.1.12 *The actual and utilised capacity of the vehicle*

Vehicle capacity is the maximum payload the freight vehicle can carry, and utilised capacity is the payload of the goods on a trip. In the analysis of daily trips from AIE to places within Chennai, we observe that the small pick-ups/vans were often not fully loaded to their total capacity and trips were more often made with part loads.

LTL shows that the trucks are underutilised in the shipment of goods from AIE to within and outside Chennai. The industries incur a loss due to the unutilised capacity of freight vehicles as they are most often charged to the total loading capacity of the vehicle. Freight trips with less than FTL also translate to more number of trips, higher fuel consumption, congestion and resulting emissions which could be reduced to a large extent by consolidation.

2.6.1.13 *Consolidation at AIE*

a) Current status on Consolidation

Manufacturers in AIE were asked if they consolidated their consignment. About 59% (figure 28) responded that they did not consolidate any of their shipments. In comparison, 33% of the sample already consolidated their shipment by using parcel service for long-distance shipments, and 8% of the sample rarely consolidate. Consolidation is not practised in AIE due to concern about the safety of their consignment, business secret regarding client details, security clearance for other

consignment clubbed in the vehicle, and assured time of delivery. They were not ready to a trade-off between business details for reduced cost of shipment.

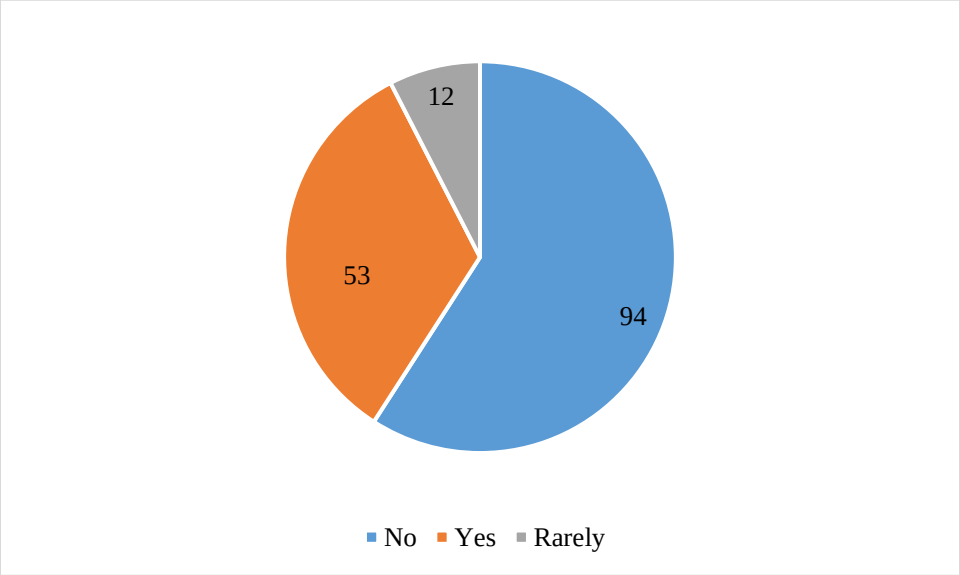


Figure 28: Current status of consolidation at AIE (159 samples)

b) Interest to participate in future consolidation

Participants were asked if they were interested in consolidating their shipment in future. The majority of them, 63% (figure 29) expressed their willingness to consolidate while 35% were doubtful about consolidation. They were ready to participate in consolidation strategies provided it would bring down the overall cost of transportation, ensure the safety of goods and assure on-time delivery of goods. Most of the people willing to participate were unaware of the current consolidating process or other industries for consolidation.

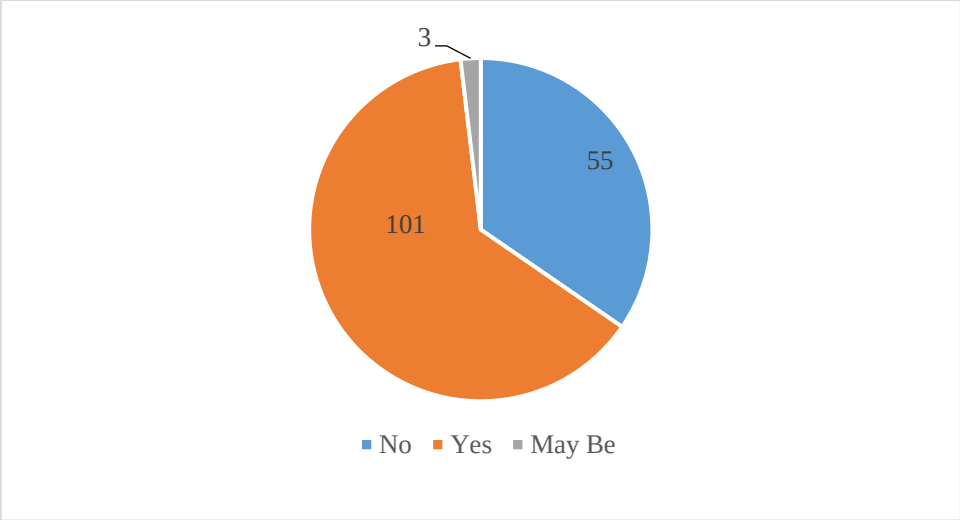


Figure 29: Interest of industries to participate in future consolidation

2.7 Target consumers

The study mainly targets any establishment in the city - any industry/manufacturer, a distributor who receives and delivers goods in part loads, and retailers as well. Most industries receive raw materials from the same location, may send their semi-finished products for further processing to other industries within the city, and dispatch finished goods to other industrial areas adjoining the city. Currently, these are individual trips with less than FTL, providing scope for consolidation (in-vehicle). Example: Manufacturer of automobile spare parts situated in Ambattur Industrial Estate (AIE) receives raw materials (steel plates, rods, tubes) from Manali, dispatches their semi-processed goods to various treatment (sandblasting, heat treatment, and painting) plants within AIE, and transports finished goods to their clients in Sriperumbudur.

At present, customers are using conventional methods like contacting truckers over the phone and or engaging those stationed nearby. Issues faced include bargaining and paying truckers much more than the optimal cost mainly because shippers are paying for FTL and truckers demand payment for both onward and return trip instead of one-way. For distant locations, parcel services are employed by industries which cost them less as they consolidate but takes a longer time to reach their destinations, making it unsuitable for urgent deliveries. Few parcel service operators do not offer door-to-door services, making it inconvenient for the customer as they have to drop-off and pick-up their parcels from nearest hubs. App-based online platforms for booking trucks available in the market have a major drawback that they do not consolidate goods, and customer/receiver must book the entire vehicle even for part loads making them costly for most shippers. Customers opt for these online bookings in case of non-availability of trucks locally and for urgent deliveries.

Industries which cannot afford to hire a freight vehicle use two-wheelers and auto-rickshaws for transporting lighter/small-sized consignments by employing own labourers resulting in loss of valuable man-hours.

e.g. Automobile spare parts industry employs a Piaggio Ape with a capacity of 0.5T to pick-up materials weighing around 0.2T from AIE to Sriperumbudur at a price of Rs.600/trip. If his goods are consolidated with goods from other industries and sent to Sriperumbudur as shown in the figure, the total transportation charges he incurs will be only Rs.400, thereby saving Rs.200.

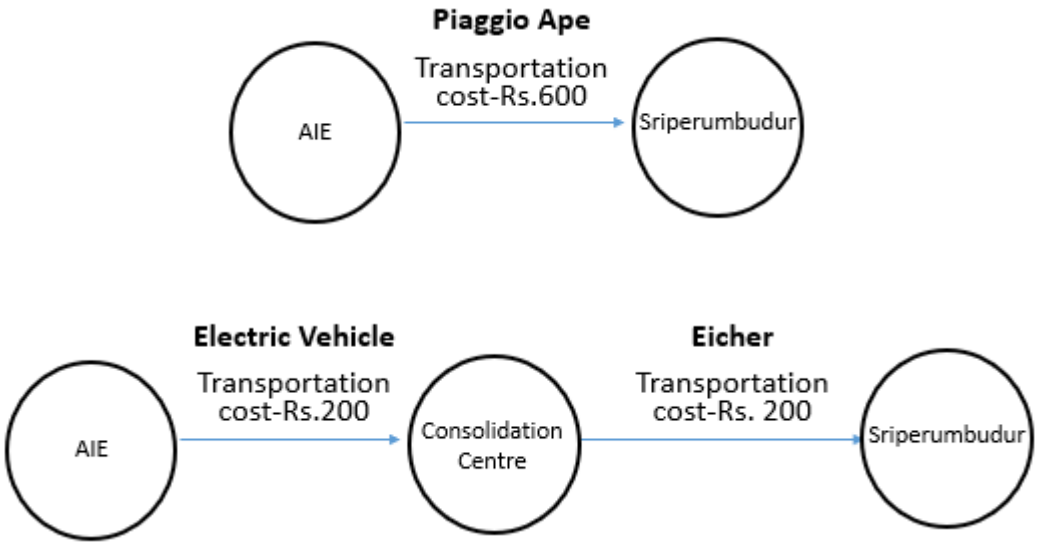


Figure 30: Example of cost reduction due to consolidation

Though the consolidation strategy has multiple benefits, there are a few instances where it cannot be feasible;

- It cannot be applied for consignments transported to smaller distances (say less than 4 km).
- Not applicable for consignments which are not packed properly such as sand, rubbles, etc.
- Transportation cost will not be fixed and will vary based on the available capacity/space in the freight vehicle and distance to be shipped.

2.8 UCC: a win-win for all stakeholders

The impact of an urban consolidation centre will be a win-win for all stakeholders. Urban freight has several stakeholders including shippers, receivers, transporters, consumers, and several

government agencies such as city municipality, police, highways department, transport department, and pollution control board. Often the cost of logistics is borne by the shipper. The shipper is also constrained by the demand of the receiver for just-in-time delivery. The shipper typically approaches his 'trusted' trucker to deliver the goods. Often the trucker charges for the full vehicle even if it is a less-than-truckload (LTL) shipment. Goods movement within the city has tremendous scope for consolidation. Providing an opportunity to consolidate ensures transportation costs are minimised without compromising on delivery times. Receivers are often the most demanding though they do not directly pay for the logistics costs. However, just-in-time deliveries and immediate/urgent deliveries have their additional costs and the shipper factors this into the overall price charged. Further, if fellow-retailers and establishments, consolidate and drive-down costs, they can offer goods and services at a more competitive rate. This forces others to consolidate as well. The reduction in logistics costs ensures a reduction in price for consumers. The general public will see the trickledown effect of the benefit reaching them in terms of lowered prices. The government agencies are fighting a daily battle of congestion, safety, and pollution. Consolidation can reduce the number of freight vehicles on the road as well as at parking spaces. Operating an optimal type and size of fleet reduces the emissions. Safety can be prioritised in a centralised/aggregated logistics operation. A disaggregate market often ignores the importance of safety. The concept of an urban consolidation centre will be welcomed by the city since it benefits multiple stakeholders.

2.9 Steps to be taken care while operating a UCC

The most important thing to be kept in mind in case of operating a UCC is that it will be beneficial only for those establishments who transport part loads but are paying for the full truckload. Also, an establishment needs to plan well ahead for transporting their commodities to give enough lead/ lag time for the consolidation manager to plan the tour accordingly by consolidating goods and optimising the truckload. If the distance between the origin and destination is too short (e.g. within Ambattur, the goods are transported to distance less than 4km), then the benefits of consolidation are less. The consolidation manager needs to be efficient in terms of knowledge about the city and should maintain healthy relations with the establishments as well as logistics operators. The goods should be properly packed and loose commodities like sand and gravel cannot be consolidated.

The absence of adequate demand will lead to making point-to-point deliveries without consolidation, leading to higher cost making the idea less competitive. So, the plan must be to initiate the market from a few selected industrial estates because it was found from the study that Small and Medium Enterprises (SME) are willing to consolidate their shipments if it reduces their

goods' transportation cost. This will enable a UCC to establish its market in these estates and scale-up. Another risk for operating a UCC is operational cost exceeding revenue. Operational cost includes the cost of operating warehouses, a fleet of freight vehicles and other administrative costs. The main aim should be to keep revenues higher than operational cost by strategically selecting the location of roadside warehouses based on the demand, thus optimising the vehicle-km and making the UCC self-sustaining.

CHAPTER 3. ADVANTAGES OF FREIGHT CONSOLIDATION

The savings in emission and reduction in vehicle kilometre is calculated for the sample size based on the survey data and only considering the from/to AIE trips that are made within 50km of AIE. The total daily trip distance was calculated using the trip distance and number of trips from the survey data. The commodities were assumed to be consolidated/combined to the full truckload (FTL) of the freight vehicle considered for that specific trip.

The table shows that a 50 - 55% reduction in vehicle kilometre travelled by small pick-up/van for trips from/to AIE. Similarly, for trips by 2-axle truck also shows 46 - 48% reduction in vehicle kilometres travelled.

Table 4: Comparison of vehicle kilometres travelled by trips from/to AIE

Direction	Vehicle type	Total daily trip distance (vehicle km)	Total daily trip distance on consolidation (vehicle km)	% reduction
From AIE	Small pickup/van	2944	1457	50
	Two-axle truck	1024	546	47
To AIE	Small pickup/ van	1597	709	56
	Two-axle truck	889	461	48

The emission savings were calculated for the cumulative trips made from/to AIE and within 50km of AIE based on the data from the survey i.e. the savings is only for the sample size considered in this study. The freight vehicles catering to AIE were assumed to be of BS-II standards for the calculation of vehicle emission. The emission factors (g/km) for CO, HC and NO from the BS-II standard for small pick-up/van 8.05 g/km, 0.86 g/km, and 8.04 g/km, respectively were considered for the calculating emission. Similarly, the emission factors for the 2-axle trucks considered are 13.92, 0.29 and 9.71 for CO, HC and NO respectively[5].

[5] On-board measurement of emissions from freight trucks in urban arterials: Effect of operating conditions, emission standards, and truck size Srinath Mahesh∗, Gitakrishnan Ramadurai, S.M. Shiva Nagendra

From the table 5 we can observe 34 - 40% in savings of the emission parameters in the from/to AIE trips made by small pick-up/van and 29 - 31% by 2-axle trucks. This savings is only for the sample size and if scaled up for all the trips made from/to AIE the reduction in emissions will be more than the values shown in table 5.

Table 5: Comparison of emission by trips from/to AIE

Direction	Vehicle Type	Actual Emissions			Consolidated Emissions			Reduction in emissions (%)
		CO (gm)	HC (gm)	NO(gm)	CO (gm)	HC (gm)	NO (gm)	CO, HC, NO %
From AIE	Small Pickup/Van	35553	3798	35509	23458	2506	23428	34
	2-axle truck	21381	445	14915	15201	317	10603	29
To AIE	Small Pickup/Van	19289	2061	19266	11415	1219	11401	41
	2-axle truck	18562	387	12948	12834	267	8953	31

3.1 Overall observations

- 66% of the industries located in AIE are small scale industries that manufacture products such as automobile parts, job work, mild steel and aluminium.
- About 30% of the deliveries are packed in boxes while an equal percentage is transported in gunny bags or loose.
- Analysis of daily trips within AIE is by small trucks and are observed to be carrying part loads. About 76% and 54% of the trips moving in and out of AIE, respectively, are less than truckload

trips. This shows the freight vehicles are underutilised and generates more trips; hence, there is scope for consolidation in AIE for both from and to trips

- 88% within 50km radius of AIE trips and 86% outside 50km radius of AIE trips are made from AIE during office hours. The respondents were concerned about the safety of the goods, difficulties in getting labour for loading or unloading and just-in-time deliveries for job work completion. The flexibility in delivery time will help us to chart out with the scheduling plan before the consolidation of shipments.
- Presently 33% of the sampled industries are consolidating their shipment by in-vehicle consolidation or utilising parcel service. About 63% of the sample expressed a willingness for future consolidation. This shows that there is a scope of consolidation in AIE.
- From the sample, it could be observed that 437 daily freight trips towards AIE and 508 from AIE made.
- On a day to day basis, around 1494 and 1574 tons of material move in and out of AIE respectively as per the sample.
- Potential outside places for consolidation are Sriperumbudur, Padi, Manali, Oragadam, Parry's Corner, Marimalai Nagar, Thirumudivakkam, Perungudi, Guindy, and Porur.
- Consolidation of LTL trips in AIE will result in a significant reduction in the number of trips (53%), vehicle km (51%), and emissions (CO-34%, HC-34%, NO-34%).

3.2 Cost-Benefit Analysis

3.2.1 Cost of Transportation

Factors that influence the cost of transporting freight are trip distance, density, stow-ability, handling, liability and planning. Trip distance is the major factor that influences the cost since it directly contributes towards variable costs such as cost of fuel, labour cost and the cost incurred for maintenance. However, the density of consignment, i.e. the space occupied by the consignment to its weight, also influence the cost of transportation to some extent. Increasing the efficiency of the freight vehicle, i.e. loading the vehicle to its full capacity in terms of weight and volume by combining more than one consignment will reduce the transportation cost of each consignment. Increase in product density reduces the unit cost of transportation. Though stow-ability and density are similar stow-ability refers to the dimension of consignment and its impact on vehicle utilisation. Regular shaped consignments are easier to stow and consolidate more than one consignment in a trip when compared with irregular-shaped such as protruding consignments and excessive weight per unit volume.

Heavy or delicate/fragile consignment requires handling equipment for loading and unloading that incurs handling cost. Handling equipment varies depending on the consignment, and the cost is higher for special equipment.

Liability is the possibility of damage to consignment (the consignment is fragile or because another consignment is stowed with it), or to theft since it is not packed well, or risk of explosion due to hazardous material.

Strategic planning has to be done in order to reduce the deadhead miles to reduce the miles travelled by empty trucks.

3.2.2 Classification of transportation cost

- Variable cost
- Fixed cost
- Joint cost

Variable cost is a cost that changes with distance or weight of the shipment. For example, labour cost, fuel, and maintenance. This cost is measured as cost per km or per unit of weight.

Fixed cost is the cost that does not change, and the company incurs even if it does not operate such as during a holiday. For example, cost of consolidation centre, manager's salary, and vehicle's rent.

Joint cost is a cost that cannot be avoided due to a decision to provide a particular service. Decisions such as backhaul cost and forward haul cost can impact transportation charges.

3.2.3 Cost-benefit estimation for AIE

Cost-benefit estimation is a process to support decision making because it provides an agnostic, evidence-based view of the issue being evaluated—without the influences of opinion, politics, or bias. A cost-benefit analysis will yield concrete results that can be used to develop reasonable conclusions around the feasibility and/or advisability of a decision or situation.

Cost-benefit analysis for setting up of a consolidation centre was performed based on the data collected from Ambattur.

Cost-benefit was estimated assuming that 80 trips/day within AIE will be done by electric vehicles, and usage of an 8-tonne freight vehicle making three trips/day to Sriperumbudur. The number of trips that are less than 1 tonnes made within AIE was reviewed to analyse the scope of electric vehicle implementation.

Table 6: Number of daily and less than 1-ton trips within AIE

	Total daily trips within AIE	Trips with tonnage less than 1 T
Trips produced from AIE	170	135
Trips attracted to AIE	180	87

Table 6 shows the trips and the tonnage per trip from AIE to Sriperumbudur as obtained from the sample (i.e. 10% of the total trips in AIE). Table 8 shows the cost and revenue for various components in the consolidation process. Monthly overall costs and revenue were estimated considering 20 working days in a month.

Table 7: Per trip cost based on the tonnage

Tonnage		Daily trips	Market cost per trip	Consolidated cost per trip
Lower limit	Upper limit			
0.20	0.40	1	600	450
0.60	0.80	14	1200	900
1.00	1.50	3	1500	1125
3.00	4.50	2	3000	2250

Table 8: Cost and revenue on consolidation of freight

Internal Trips (80 per day with 4 EVs)					
Item	Qty	Rate	Unit	Costs	Revenue
Rent	1000	30	per sq. ft. per month	30000	
E-trikes	4	5000	per vehicle per month	20000	
Power + op costs	6400	2	Rs. per km	12800	320000
Driver costs	4	16000	per month	64000	
Consolidation	1	35000	per month	35000	

manager					
Helper costs	4	10000	per month	40000	
Forklift charges	1	65000	monthly hiring cost	65000	
Server charges	1	10000	per month	10000	
External Trips (AIE to Sriperumbudur)					
Truck rent	3	3750	per truck trip to Sriperumbudur	225000	418500
Helper	2	10000	per month	20000	
OH + Taxes	25%			173933	
Total (Rs per month)				**695733**	**738500**

Analysis of cost–benefit is assuming 25% overall savings for both the customer and the trucker. By participating in freight consolidation, the customer pays only for the part load, and transporter earns an extra amount per trip.

Some important points to be noted while performing LTL shipping are:

- Pick-up and/or delivery timings should be flexible
- LTLs shipped to distances less than 4 km is difficult to consolidate
- Loose items, i.e. unpacked consignment are unwieldy to consolidate
- Transportation cost will vary based on the available capacity/space in the freight vehicle and distance to be shipped.

CHAPTER 4. DEVELOPMENT OF MOBILE APP

An app-based consignment booking was designed in order to facilitate the consolidation of goods to utilise freight vehicles more efficiently by reducing the number of LTL trips and the cost per trip paid by the customer. Consolidation of goods will result in a decreased number of freight vehicles on the road, reduce pollution due to tailpipe exhaust and traffic congestion. The app was designed based on the understanding and observation made from the face-to-face interviews and survey conducted at Ambattur Industrial Estate (AIE).

4.1 Objective

The mobile app aimed to consolidate various consignment based on the data or specification provided by the industries/manufacturers during the booking process. The result of consolidation will be the reduction of shipment fare compared to the current fare of each trip.

4.2 Design and process involved

The mobile app focuses on four target users, namely customer, truck owner, consolidation manager and administrator. Three separate mobile apps were developed, and the admin console is a web-based application.

4.2.1 Customer app

A customer (i.e. receiver or shipper) registered in this app will be able to place an order to pick-up/ deliver his shipment through this app by specifying information such as pick-up and delivery location, time, shipment details - commodity type, package type, volume and weight of consignment.

Various tab designed and incorporated in this app is as follows:

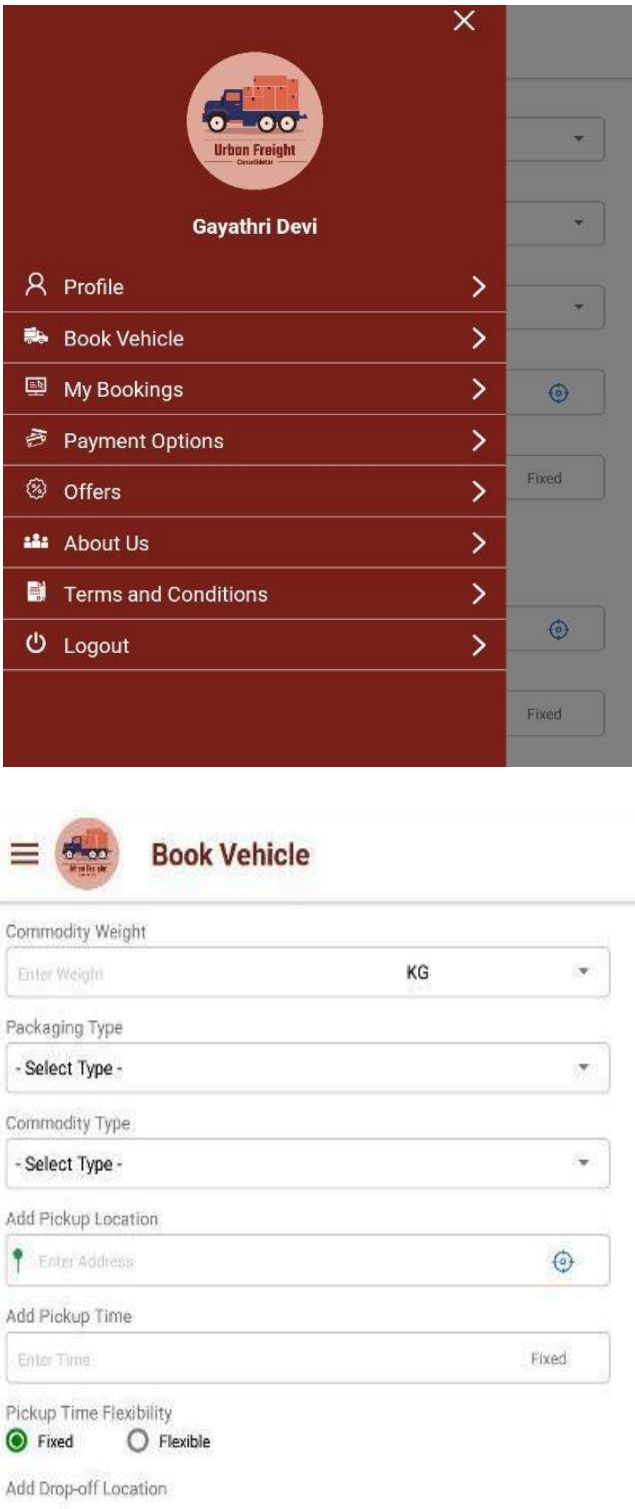


Figure 31: Image of "Customer" app

- Profile: Registered customers can add, edit and store Customer's Company name and contact information. The customer can also add, edit and store up to 10 addresses that can be used for pick up or delivery locations.

- Book Vehicle: Customer can furnish shipment pick-up and delivery address, commodity details and time of pick-up and delivery. The pick-up or delivery time can be fixed where the consignment has to be picked up/delivered at the time specified by the customer or flexible with 30 minutes to 2 hours window of the time specified by the customer. The customer types in the shipment data to book vehicles and this data will be sent to the consolidation manager to schedule/assign a vehicle for this booking. Each booking will be given a booking ID.

- My Bookings: All the current bookings of the customer will be listed on this page. The manager will send the fare for each booking to the customer. The customer can proceed with the payment transfer if he/she agrees to the fare. After the payment is transferred for that specific booking, the customer has to upload the transaction ID to confirm the order and only then the manager will proceed to allot/assign a vehicle.

- Payment option: Payment gateway/ portal is not part of this app. The account details of the consolidation manager or the third party in control of the app will be provided. The customer has to transfer payment to this account and upload the transaction ID.

- Offers: Any offers or discounts for the customer provided by the third party or the consolidation manager will be displayed.

- About us: A brief description about IIT Madras and the team involved in developing the app.

- Terms and conditions: Terms and conditions for users of this app. Copyright statement

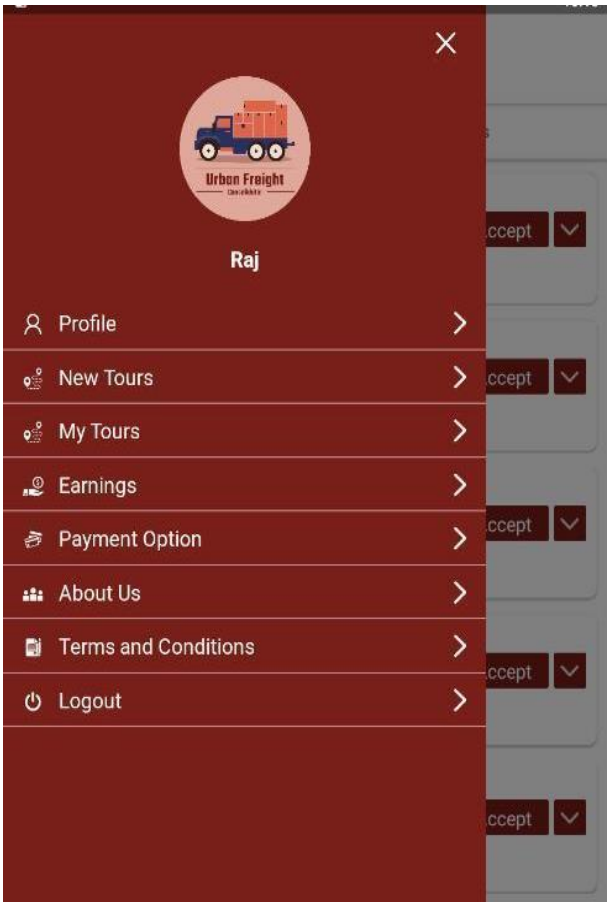
- Logout: sign out from the app to protect the account from strangers using it.

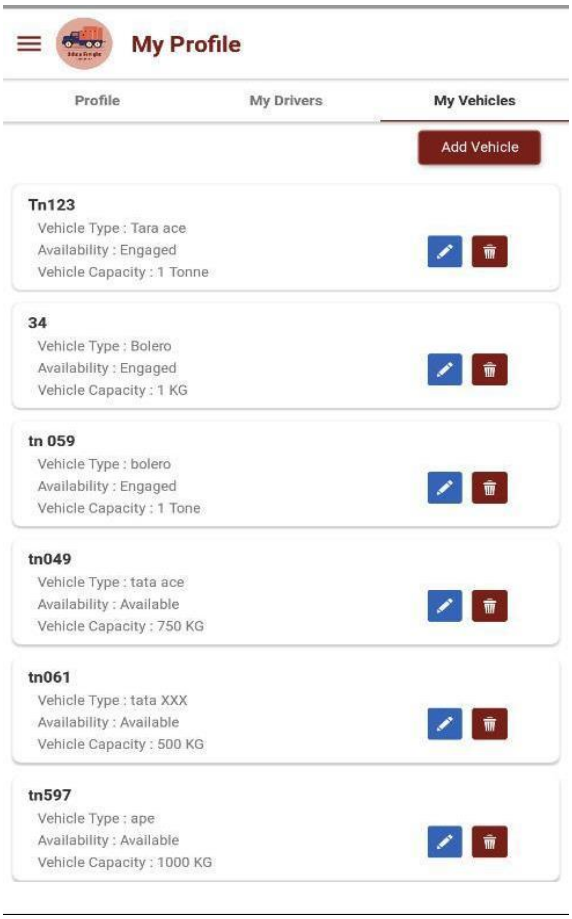
4.2.2 Truck Owner app

A truck owner can register in this app to avail the service, and they can seamlessly navigate booking requests and accept shipment bookings/tours.

- Profile: Registered truck owners can add, edit and store his company address and contact information. Vehicle information such as vehicle registration number, model and year that is associated with his company can be edited and stored for a maximum of 10 vehicles. Information –

name and mobile number of drivers associated/connected with the company can be added, edited and stored on this page. A maximum of 10 vehicles and 10 drivers information can be stored in a truck owner profile





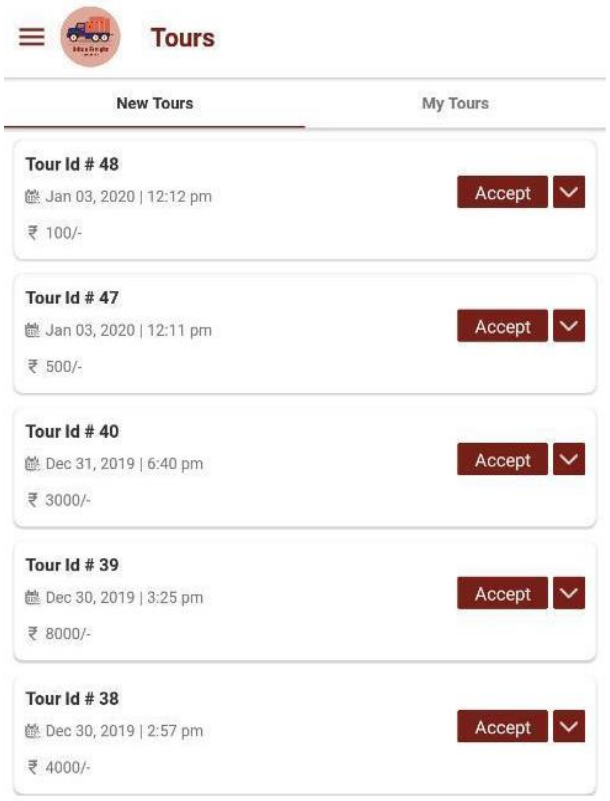


Figure 32: Image of "Truck Owner" app

- New Tours: The consolidation manager will share the tour details with pick-up/delivery location, commodity type, commodity volume, commodity weight together with the fare of the tour. A truck owner willing to accept a tour for the specified fare will confirm by pressing the accept button. When the tour is accepted by a trucker, this tour details will 'haze out' for other truck owners, and that particular tour will become inactive.
- My Tours: Tours accepted by the truck owner will be listed on this page. The status of the shipment can be updated by the trucker.
- Earnings: List of tours he has completed with the earnings will be displayed. If the payment is pending from the consolidation manager, it will be listed under pending. On receiving the payment the truck owner has to confirm, and these tours will be listed under the confirmed payment tab.
- Payment Option: The account details of the truck owner to which the payment has to be transferred will be displayed.
- About Us: Brief description about IIT Madras and the team involved in developing the app.

- Terms and Conditions: Terms and conditions for users of this app. Copyright statement
- Logout

4.2.3 Consolidation Manager app

This app enables a consolidation manager to optimise truckload, assign trip, manage customers and truck owners. The tabs and its functions are as below.

- Profile: Consolidation manager can furnish his details- name and contact information. Each consolidation centre will have a unique ID with the location.
- New Bookings: List of all bookings with shipment details provided by the customer will be displayed under the pending quotation. Unique booking ID will be created for each booking when a customer places an order. The manager calculates the fare for each booking and shares with the customer and the booking will be displayed in the booking status page. The booking is confirmed only when the payment is received from the customer.
- Confirmed Bookings: Bookings for which payment has been received will be displayed in confirmed bookings page. The consolidation manager can view the details of the booking. During the consolidation process, if there are other shipments to be delivered to the same location as the destination of a specific booking, the consolidation manager can change the destination of the shipment to be delivered to the consolidation centre. He can then consolidate and then schedule the combined delivery of shipments from the consolidation centre.
- Tour status: A tour consists of one or more bookings combined by consolidation manager based on the shipment details, and each tour will be assigned a unique ID. Consolidation manager will calculate the fare and share the tour details to all the truck owners. The tour will be displayed under pending until a truck owner accepts a tour. After the acceptance of the tour, it will be displayed under the accepted tab.
- Customers: This page contains a list of Customers, and their information such as company address, pick up/ deliver address furnished by them in their “Profile” page

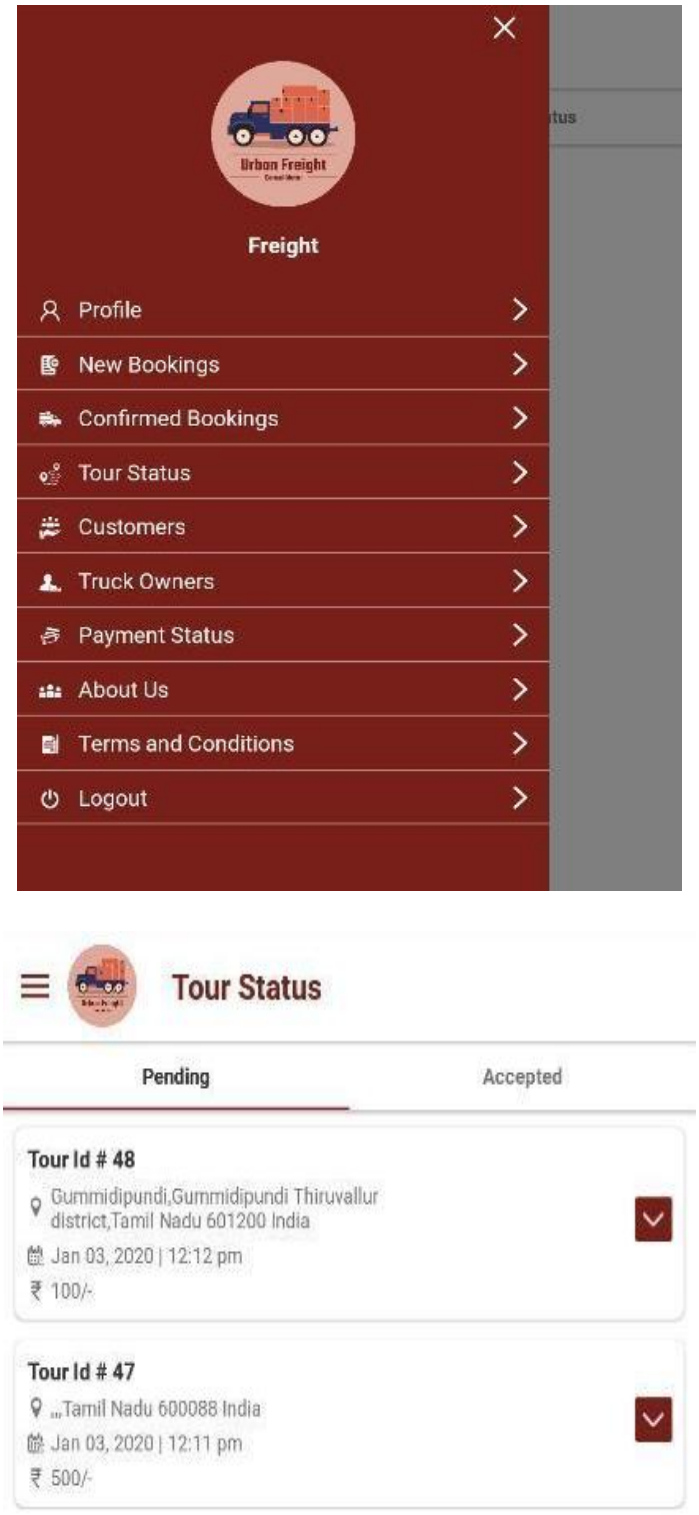


Figure 33: Image of "Consolidation Manager" app

- Truck Owners: This page contains a list of Truck owners, and their information such as an address, vehicle details and driver details furnished by them in their "Profile" page.
- Payment Status: Pending page contains a list of tours for which payment has not been initiated by the consolidation manager. The confirmed page will contain a list of tours for which payment has been transferred to the truck owner.
- About Us: Brief description about IIT Madras and the team involved in developing the app.
- Terms and Conditions: Terms and conditions for users of this app. Copyright declaration statement
- Logout

4.2.4 Admin Web Application

The administrator is responsible for reviewing the feedback of customer and truck owner, on-time delivery by the truck owner, payment issues, and support and guides the consolidation manager. He has the power to edit/ change decisions or fare suggested by the consolidation manager. The administrator is responsible on the whole for the function of the app and seamless service.

- Dashboard: contains a brief about the number of bookings, tours, and payment made on that specific day.
- Booking: A list of bookings with booking Id and complete details of the bookings are displayed with the shipment status, i.e. in-transit, pending or delivered.
- Quotation :List of bookings with its fare and customer status, i.e. accept, payment paid or cancel is displayed
- Tours: Admin can view details of tours such as tour ID, tour date and time with the fare to be paid to the truck owner and status of the shipment.
- Users: list of customers, truck owner and consolidation registered with the app with name and mobile number can be viewed by the admin. Admin can delete the user if they are no longer associated with the app.
- Payment: Payment details such as fare, the status of payment and transaction ID for Customer and truck owner that can be edited by admin
- Report: this page has combined information of the bookings, tours, truck owner profile with details of vehicle and drivers associated with them, customer profile with contact information and number of bookings and payment made. Data can be exported in excel format for any analysis purpose.

- Set up; admin can edit/ change the contact information of consolidation centre, unit of the commodity size and weight

The source code for the app is available for download at the following link:

https://drive.google.com/file/d/1QQ4UCwLk-TcKsFEQVkSOFgkL8pGpajmA/

CHAPTER 5. CONCLUSIONS

The responses of the survey conducted in Ambattur Industrial Estate (AIE) helped us to understand the characteristics of freight trip, and patterns from/to AIE such as of the number of daily trips, the quantity of shipment handled every day, the freight vehicles preferred and the average daily freight cost incurred. Analysis of the response showed us the probability or scope of consolidation in AIE. A mobile app (Android) was developed to facilitate freight consolidation by customer booking the trip through the app and consolidating the freight based on criteria such as delivery time, volume, weight and origin/destination location, followed by identifying the trucker to complete the tour.

The consolidation process would result in over 50% reduction in the daily vehicle KM travelled from/to AIE, 30 – 40% reduction in tailpipe emission and would also prove cost-effective – per trip cost for the truckers as well as the customers will be reduced by about 25%. The consolidation strategy can be implemented in any industrial area that is similar to AIE, and it is advised to do a pilot test before implementing the consolidation strategy since freight trip patterns and characteristics vary across industrial estates.

5.1 Steps city needs to follow to undertake a UCC

Every city is unique in its characteristics, and therefore a thorough study is essential before setting up an urban consolidation centre. The following broad steps may be followed:

- **Estimate the freight demand**

The first step is to understand the nature of freight movement happening in the area chosen. Getting a clear picture of the type of freight vehicles used, quantity, time of deliveries, type of commodities shipped, the proportion of part loads, and the cost of transportation. If and only if there is sufficient demand to ship the commodities, the UCC becomes feasible. Questionnaire surveys, face-to-face interviews with open-ended questions, and telephonic interviews can be used to collect information.

- **Estimate the number of users likely to use**

For an establishment to use a UCC, the major criteria are safety, cost and on-time deliveries. The flexibility in the time of deliveries makes it easier for consolidation and hence can be used to estimate the market size. Proper safety measure needs to be adopted while transporting the goods as multiple consignments are shipped in a single truck. Though the cost of transportation becomes lower when goods are consolidated, the sensitivity of an establishment to cost needs to be understood. Accurate information on these factors can help a city estimate the number of users which is highly critical to the success of a UCC.

- **Choose an appropriate location for UCC**

UCC should be located in a place that is quickly accessible to the establishments who participate in consolidation. If a central location is chosen, the land value may be high, whereas if outskirts are

chosen, it may increase the 'first-mile' cost of transportation. Therefore, there should be a trade-off between the value of land as well as the first-mile cost.

- **Estimate the cost-benefits of operating a UCC**

There are various cost components associated with running a UCC which needs to be thoroughly studied. Based on the freight demand, the number of establishments needed to participate so that the costs such as rental charges of a UCC, manager salary, additional first mile and last mile delivery cost can be taken care of. Though subsidies to operate a UCC may be beneficial in the beginning it should ultimately be self-sustaining to operate for a longer run.

- **Government support**

Though not necessarily by means of providing direct subsidies, the government can support the concept by providing parking fee subsidy and free access to trucks which participate in consolidation. In future, electric vehicles always are likely to be more economical over conventional ICE vehicles, and hence incorporating those can be an effective measure for the success of UCC. Supporting regulations and innovative traffic management measures favouring UCC need to be thought about depending on the city.

5.2 Scope for further research

Route optimisation algorithms can be considered in the app, which helps in consolidating the goods without creating a hurdle for the consolidation manager who now plans the tour manually in the UCC app. If electric freight vehicles are employed for last-mile deliveries, it will be advantageous in reducing emissions and the cost of operations. In such cases, parking of those electric vehicles and their charging facilities should also be considered.