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Characteristics of Urban Freight Traffic in a Medium Size Indian City – A Case Study of Udaipur, Rajasthan

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Abstract

Goods Traffic constitute an important component of traffic of traffic flow in Urban area. However, Urban Freight is not a very well understood among the administrators and decision makers, especially in Indian cities. In order to make our cities sustainable, this particular field of transport planning is extremely important because an efficient and effective logistics sector is vital to the economy. New models for management of freight are required in urban areas in which, the local authorities need to play a proactive role. In larger cities, there are still some considerations towards the urban freight but in the emerging medium size cities, it is completely missing. So, this paper attempts to contribute towards laying a groundwork towards understanding of the characteristics of urban freight logistics in medium size cities of India. For this, detailed primary surveys were done in the case city Udaipur and they have been used to create a profile of Freight Generating and Freight Handling areas in the city, along with detailed understanding of Supply Chain of the most important commodities.

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1. Introduction

Freight transport is the most important aspect that supports the global supply chains of the commodities, right from the procurement and conversion of raw materials to the distribution in the market and the services thereafter. A logistics sector, which is efficient as well as effective, is a vital element of the economy due to its enabling effect (*UNDP and MoUD, GOI, 2016*). As the economic activities in urban areas expand and their population increases, a large quantity of urban freight traffic is generated. The well-timed and unobstructed movement of this freight is extremely critical to

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the well-being of the population and the feasibility of the economic activities that they support. Freight induced traffic and the movement of goods in the city, along with by-passable traffic affects the overall mobility in the city.

Cities are dominant centers of production and consumption. So, most transport, including both of passenger and freight, usually starts and ends their trip in the urban areas and on their way, they often bypass through several urban areas. Hence, urban activities are mostly go with by large movements of freight which are characterized by delivery trucks moving between - industries, distribution centers, warehouses and retail activities as well as to and from major gateways such as ports, rail terminals, distribution centers and airports (Rodrigue, et al., 2006). .). Goods traffic represents a considerable proportion of urban traffic volume. Although in most cities on average 15-20% of the vehicle kilometers (four wheel or more) travelled can be attributed to commercial vehicles, it is estimated that they take up roughly 20to 40% of motorized road space occupation and cause 20 to 40% of CO₂ emission (GTZ, 2010). Further according to (Deblanc & Rakotonarivo, 2010) on the level of a typical metropolitan area in a developing country, on average 40-to 50% of commercial vehicle freight volume is incoming, 20-25% is outgoing and the remaining 25-40% are intra metropolitan runs.

The urban freight is usually faced with a variety of challenges including traffic congestion, parking for vehicles involved in delivery of goods and the reverse logistics (e.g. recycling, garbage collection, etc. Some of the factors which act as barriers to sustainable urban goods movement are the lack of awareness, understanding and overall vision to urban goods movement. In addition, lack of information about flow of urban goods movement, fragmentation in nature of stakeholders and gaps in skills and knowledge are also contributory factors leading to neglect of urban freight sector. There is also an absence of coordinated urban freight policy involving various stakeholders such as transport operators, planners, decision makers, local authorities etc. Besides there is also an absence of integration between urban freight in town planning and land use/infrastructure planning leading to logistics sprawl. Some of the problems induces by the urban freight traffic directly affect the overall life and the safety of urban dwellers, while others contribute towards global challenges like Greenhouse Gas (GHG) emissions. According to (Dablanc, 2006) urban goods transport (including transiting heavy goods vehicles) accounts for 18% of vehicle km, 31% of the energy use and 31% of the CO₂ emissions respectively.

Goods vehicle constitute an important component of the traffic flow on the road system in urban areas. While macro level freight traffic data base is generated as part of comprehensive transport plan preparation exercise undertaken from time to time, the freight logistics aspects related to supply chain linkages, storage, handling, distribution including the modes used etc. is not given enough importance. Very limited studies have been carried out in India which are focused on urban freight movement aspects. According to one of such study carried out by CRRI, it is observed that goods traffic generally tends to vary consistently with respect to city size, its economic base and its location (CRRI, 1998). For medium size cities, the study estimates that the daily inter-city inbound freight volume varies between 2,884 tonnes to 17,103 tonnes, the daily inter-city outbound freight volume varies between 143 tonnes to 10,805 tonnes and the daily intra-city freight volume varies between 215 tonnes to 2,888 tonnes. However, the actual volume of freight handled in a city depends upon the locational and economic characteristics.

2. Profile of Case City of Udaipur

The former capital of erstwhile Mewar Kingdom, Udaipur at present, is a medium-sized city, a Municipal Council and the administrative headquarters of the Udaipur District in the State of Rajasthan in India. The urban control area (UCA) of Udaipur had a population of 6.4 lakhs (Census of India, 2011) and as per the estimations made in the study, it is estimated to have been increased to about 7.3 lakhs by 2017. Also, the population of Udaipur city (municipal area), in the year 2017, has been estimated to be about 5.6 lakhs.

Udaipur is situated in the north-eastern part of Girwa Tehsil of Udaipur District, and the south-western part of Rajasthan. Located almost at the midpoint of the Delhi-Mumbai National Highway (NH8), It is well connected to the state capital Jaipur (420 km to the north-east) and Ahmedabad (250 km to the south-west). It is also connected to other

prominent state centers by three state highways: NH-48 connecting Jaipur as well as Ahmedabad, NH-76 connecting Chittorgarh; SH-32 connecting Banswara; and NH-27 connecting Mount Abu (UMTC, 2015).

Udaipur is primarily developing in the north, east and south directions, along the NH-8 to Ahmedabad and NH-76 to Chittorgarh. The region towards the west is blocked by hills and lakes and so, did not develop further. The north-eastern part of Udaipur is a plain area, and therefore secondary and tertiary activities have been increasing in this direction for some time (CRISIL, 2014).

2.1. Area and Population

The Udaipur Urban Control Area of Udaipur was created to curtail any unplanned development (Table 1.). This is a boundary with a radius of 3-4km around Udaipur. The boundary consists of municipal area, as well as urbanized and urbanizable areas, along with 62 revenue villages.

Table 1. Area and Population of Urban Control Area of Udaipur

S. No.	Part of UCA	Area (Ha)	% of Total Area	Population (2017)	% of Total Population	Density (Persons / Ha)
1.	Rural Area	26,921	81 %	1,71,374	23 %	7
2.	Municipal Area	6,202	19 %	5,58,683	77 %	91
	Urban Control Area	34,791	100 %	7,30,057	100 %	21

Source – Master Plan of Udaipur (2011-31) and estimations made through Census of India Data (1951-2011)

The land within the Urban Control Area can be utilized for agriculture, dairy, horticulture, farm houses, resorts, motels, amusement parks, water parks and agriculture-based industries. The boundary of the Urban Control Area has been fixed to promote a planned development of villages.

2.2. Land Use Characteristics

Udaipur is surrounded by hills and lakes, which physically hinder its growth along these directions. Therefore, the city is presently growing only towards the north-east and west along the two national highways NH-48 and NH-76. The Master Plan (2011-31) proposes additional developments in Urbanizable area which, including the existing development, will make a total developed area of 17,967 Hectares in Udaipur (TCPO Rajasthan, 2013).

2.3. Levels of Freight Distribution in Udaipur

In total, about 89,549 tonnes of freight is generated in Udaipur. The flow of this volume of freight has been studied at two levels of distribution – (1). Tier – 1 Distribution which includes the distribution of regional freight either directly to wholesale markets/agricultural products markets/dairy or from industries to other states/regional center, and/or through interchange at a freight handling area like a transport nagar and (2). Tier – 2 Distribution which includes distribution of freight from wholesale markets / agricultural products markets/dairy to the retail markets or centers or production from Medium and Small Scale Enterprise (MSME) to distribution centers within the study area.

3. Profile of Freight Generating Areas

Three types of areas have been considered from where, the majority of freight is generated in the UCA of Udaipur including –

- Commercial Areas
- Agricultural Produce Market
- Milk Dairy (Saras Milk Dairy)

3.1. Commercial Areas

These are mostly situated within the municipal limits of Udaipur city. Among them, almost all the wholesale-cum-retail establishments are situated in or around the walled city area (like Ashwini Bazar, Bapu Bazar, Hathipole, Suraj Pole, etc.) and purely retail ones are outside walled city (like Hiran Magri, Saheliyo ki Baari, etc). All these markets serve as the intermediate distribution centers in the city (Table 2.).

Table 2. Brief information about the commercial establishments in Udaipur

Characteristic	Location		Total
	Walled City	Outside Walled City	
Area (Ha)	216	102	318
Percentage of UCA (%)	2.7%	1.7%	4.4%
Nature	Wholesale-cum Retail	Retail	-
Freight Handled (Tonnage)	6,632	4,617	11,249
Number of Establishments	4,198	1,325	5,523
Average Freight Handled per Establishment (Tonnage)	1.6	3.5	2
Employment	9,429	11,684	21,113

Source – Primary Survey (2017)

Almost all kinds of commodities are sold in the markets of walled city but there are a few specialized markets too like Sukher (marble market), Reti Stand (construction materials), etc. As Udaipur is one of the main exporters of Marble in India, the number of marble shops per lakh population is the highest. The textile trade is the highest employment generator in the city. However, bulk commodities based establishments like metal minerals, marbles etc. creates higher number of indirect employment opportunities. Approximately 11,249 tonnes of freight, that is comprised of 16 major commodities, are handled in these markets every day (Table 3.) –

Table 3. Flow of freight in commercial areas of Udaipur

Markets	Inbound Freight (Tonnage)			Outbound Freight (Tonnage)	Total (Tonnage)
	External – Internal (E-I)	Internal – Internal (I-I)	Total Inbound Freight		
Within Walled City	978	4,409	5,322	1,314	6,632 (59%)
Outside Walled City & within UCA	411	3,152	3,627	985	4,617 (41%)
Total (All Markets)	1,389	7,560	8,950	2,299	11,249

Source – Primary Survey (2017)

80% for the total tonnage, considering all the commodities, come from places which are 100 kilometers or farther from Udaipur. Majority of them are transported by trains or by hauliers through high capacity vehicles like trucks, multi-axle vehicles, etc. and unloaded at Transport Nagars, Godowns/Warehouses and Inland container depot which are located outside the municipal limits and within the UCA.

3.2. Krishi Upaj Mandi (Agricultural Produce Market)

Established in 2005, Agricultural Produce Market is a centralized and regulated wholesale market for all kinds of agricultural and forest products, managed under Agricultural Produce Market Committee (APMC) of Udaipur. It serves as a market center for the city as well as smaller towns in the region. It is located at a distance of 2 km from Udaipur railway station. Facilities and services available in the market include storage, canteen, water and sanitation, post office, banks, auction platform, parking, and rest houses. The total area of the market is 25.4 hectares and it has

about 74% of the area share of warehousing in Udaipur. 6,579 tonnes of agricultural and forest products are handled every day in this facility. It is sub-divided into different specialized areas (Table 4.) –

Table 4. Markets within the Agricultural Produce Market in Udaipur (2017)

S. No.	Sub-Market	Area (Ha)
1.	Grains	15
2.	Forest Products (under construction)	8
3.	Fruits and Vegetables	2.4
TOTAL		25.4

Source – *Primary Survey (2017)*

Out of 23 hectares of area in the grain market, 15 hectares is dedicated to food grains while remaining 8 hectares is under construction and is dedicated for forest products. The market has a capacity to store about 1,000 tonnes of grains at a time. There are 282 establishments within the Grain market out of which, 118 are godown-cum-retail establishments and 164 are retail establishment. Also, there are 2 cold storages and many other facilities like Parking, Banking, Fuel Filling Station, Rest House, etc. within the market area.

The grain market receives majority of grains from Jharol and Khelwada districts of Rajasthan but also gets some from other states like Punjab, Uttar Pradesh, Haryana and Delhi. They are all stored in the market and then transported either to the various Wholesalers, Retailers or Hawkers of Udaipur City, or to other states like Gujrat, Maharashtra, Madhya Pradesh, Jammu & Kashmir, etc. From those wholesalers and retailers, it finally reaches the consumers. Forest products mainly arrive from within the Udaipur district or from some neighboring districts too. From, Agricultural Produce Market, they are transported to the agricultural produce market in Ahmedabad (Gujrat) and then from there, further to Ports and then abroad.

As mentioned, Fruits and Vegetables Market of Agricultural Produce Market has an area of about 2.4 hectares and comprises of 175 retail shops of varying sizes. It also has 11 storage areas, including Godowns and Cold Storages. The total capacity of Godowns is about 1,000 tonnes and same that of cold-storage. The vegetable and fruit market receives majority of commodities from Gogund, Jharol, Kalisia, Markanpur, Khed, Salumbar and Jaismand but also gets some from other states like Gujrat, Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka and Delhi. They are all stored in the market and then transported either to the various Wholesalers, Retailers or Hawkers of Udaipur City, or to other places like nearby villages, Chittorgarh, Jaipur, Delhi, Bhilwada, Ahmedabad, etc. From those wholesalers and retailers, it finally reaches the consumers.

A comparative profiling of the operational characteristics of Grain Market and Vegetable & Fruits Market is shown (Table 5.)

Table 5. Operational characteristics of Markets in Agricultural Produce Market of Udaipur

S. No.	Category	Sub-category	Characteristics	
			Grain Market	Fruits & Vegetables Market
1.	Traders	Registered Traders	980	425
		Registered Shopkeepers	180	47
		Registered Brokers	90	56
		Sub-Total	1250	528

2.	Commodities Handled		Grains & their by-products, oils, ghee, dry fruits, spices	Ginger, colocasia root, bottle gourd, brinjal, coriander, tomato, mint, cauliflower, mango, guava, etc.
3.	Turnover Details	Average Annual Freight Arrival (Tonnage)	8.69 lakh tonnes	1.3 lakh tonnes
		Daily Freight Arrival (Tonnage)	2,500 – 3,500 tonnes	350 – 450 tonnes
		Daily Freight Departure (Tonnage)	500 – 1,200 tonnes	150 – 200 tonnes
Carrier Handling				
4.	Number of Carriers handled per day	Light Commercial Vehicles (LCV)	400 – 500	60 – 70
		Trucks	100 – 150	20 – 30
5.	Average Payload (tonnes)		<ul style="list-style-type: none"> • LCV – 2 • Trucks - 15 	<ul style="list-style-type: none"> • LCV – 0.65 • Trucks - 9
6.	Average Vehicle Kilometers Travelled		500 km	700 km
7.	Average Tonne Kilometers Travelled		850 km	175 km
8.	Loading / Unloading Time	LCV	0.5 – 1.5 hrs	0.5 hrs
		Trucks	1 – 3 hrs	1 hr
9.	Average Dwell Time (per Truck)		6 – 7 hrs	4 – 5 hrs
10.	Transportation Cost	3-wheeler LCV (within 10 kms)	Rs. 200 – 250 per tonne	Rs. 200 – 250 per tonne
		4-wheeler LCV	Rs. 500 per tonne	Rs. 500 per tonne
		2 Axle Truck	Rs. 1500 per tonne	Rs. 1500 per tonne
		3 Axle Truck	Rs. 3000 per tonne	-
		Trading Commission	1.6 %	6 %
11.	Other Charges	Loading / Unloading	Rs. 10 per bag	Rs. 5 – 10 per bag
12.	Operational Timings		9 AM to 6 PM	6 AM to 2 PM
13.	Employment	Direct	852	350
		Direct employment per establishment	3	2
		Indirect	1,000	400

Source – Primary Survey (2017)

An estimated 6,579 tonnes of freight traffic comprising of commodities like food grains, fruits, vegetable and forest products, is handled daily in this market (Table 6.) –

Table 6. Flow of freight in Agricultural Produce Market of Udaipur

Market	Inbound Freight (Tonnage)			Outbound Freight (Tonnage)	Total (Tonnage)
	External – Internal (E-I)	Internal – Internal (I-I)	Total Inbound Freight		
Agricultural Produce Market	3,400	1,775	5,175	1,404	6,579

Source – Primary Survey (2017)

Most of this freight arrives at market by trains or by hauliers through high capacity vehicles like trucks, multi-axle vehicles, etc. or even through Light Commercial Vehicles (LCVs), but from there, they are transported to the mentioned destinations through road based modes only, i.e., LCVs for local distribution and heavy vehicles for Inter-city distributions.

3.3. Saras Milk Dairy

Established in 1972, Saras Dairy Co-operative is located in Govardhan Vilas in Udaipur and it is a part of three tier system wherein, farmer members own Dairy Co-operative Societies (DCS) which own District Milk Producer's union. The unions collectively own the Rajasthan Co-operative Dairy Federation Limited (RCDF Ltd.). Under this, the village societies supply the raw milk to the dairy and in return, they receive incentives and cattle feed from the dairy. The plant is a 6.6-hectare large facility with capacity to process 60,000 liters of milk per day. 79% of the milk is supplied into the market on daily basis, out of which, 31% is supplied in the Udaipur City. However, per-capita of Milk supplied is 0.042 liters due to the presence of other competitors like Amul, Local Milkman, etc.

Every day, about 1,00,000 tonnes of milk is procured by Saras dairy. After processing, 79,000 tonnes of milk is supplied for direct consumption and rest is used to produce 1,088 tonnes of milk products. The village clusters, from where the procurement of milk is done, are 17 in number and are located in Udaipur and Rajsmand districts. The collected milk is stored in bulk milk coolers on site, which are 191 in number, spread across both districts, with different capacities ranging from 500 liters to 2,000 liters and their collective capacity is about 20.5 kiloliters. These collected milk are then transported to Saras Dairy Plant in Udaipur through insulated two-axle trucks. After processing in the plant, milk and other milk products like clarified butter (Ghee), table butter, etc. are then transported to 5 Saras Milk Parlors, 80 Milk Booths and 350 individual agents across the two districts by the similar insulated trucks. From these centers, these products then reach the consumers mainly by door-to-door distribution.

The RCDF Ltd. supplies cattle feed to the village clusters along with incentives. They procure the feed from Ajmer and Jodhpur in Rajasthan and first transport it in bulk to Saras Dairy in Udaipur through high capacity trucks and MAVs and from there, they apportion it and individually send them to the 17 Village Clusters Society Offices. From there, the cattle feed is then distributed to individual cattle owners.

3.4. Marble Market in Sukher

Marble is found in large quantities at Udaipur and has always been a popular medium for creative artisans. Small statues made of marble, fountains, stair cases, decorative wall paneling, and marble furniture are very popular. Thin tiles of marble are used to paint attractive pictures using different types of colors, and these tiles are used as decorative wall hangings and tabletop decorative articles. All these, along with large marble slabs which are used in construction, are prepared in Udaipur. So. It is a huge sector and creates many employment opportunities there.

The marble Market in Sukher was established in 2980 and is spread over an area of 160 hectares in the northern periphery of the city and has a very good connectivity due to the presence of National Highway (NH-58). In the 160 hectare of area, there are 120 Gangsaw units for marble cutting, 450 marble polishing units and 28 retail shops. The marble products are of two types – (1). Processed, like marble slabs, tiles, blocks, artifacts and (2). Unprocessed, like green marble, white marble, granite, brown & pink marble, katni marble and italian marble. They have a very complex supply chain.

Most of the raw marble are mined out of the areas nearby Udaipur like Rishabh Dev, Jhalore, Banswad, Raisamand, Babar Mal, etc. or even from other places like Katni in Madhya Pradesh. They are brought to the Marble industry in Sukher where they are processed in final products which have been mentioned above. Some of them are supplied into the local wholesale/retail markets or the handicraft markets and most are transported to Transport Nagars or Inland Contained Depot from where, they are either distributed to different parts of the country or even exported outside the country through ports. The by-products of marble like soap stone, which are obtained in preparing the marble products in Sukher are transported to Mewar Industrial Area (MIA) in Udaipur where they are further utilized in other products.

Table 7. Operational characteristics of Marble Market in Sukher, Udaipur

S. No.	Parameter	Characteristic
1.	Timings	9 am – 8pm
2.	<u>Employment Details</u>	
	Direct Employment	3000
	Indirect Employment	2500
	Direct Employment per Establishment	3-6
3.	<u>Turnover Details</u>	
	Average Turnover	Rs. 2000 Crore
	Average Daily Turnover	Rs. 5 Crore.
4.	<u>Functioning Details</u>	
	Average Quantity Handled Per Day	1700-2000 Tonnes
	Average Quantity For Local Distribution	90-120 Tonnes/Day
5.	<u>Carrier Handling Details</u>	
	Number of Vehicles Handled per Day	70-80
6.	<u>For Procurement</u>	
	Trucks (2 axle and MAV)	90-100/Day
7.	<u>For Distribution (City)</u>	
	3W and 4W LCV	40-50/Day
8.	Average Payload	8.5 Ton
9.	Average Vehicle Km Travelled	255
10.	Average Tonnage Km Travelled	150

Source – Primary Survey (2017)

An estimated 2,406 tonnes of freight traffic, comprising of marble products and by-products, are handled daily in this market (Table 8.) –

Table 8. Flow of freight in Marble Market of Udaipur

Market	Inbound Freight (Tonnage)			Outbound Freight (Tonnage)	Total (Tonnage)
	External – Internal (E-I)	Internal – Internal (I-I)	Total Inbound Freight		
Marble Market, Sukher	1,157	483	1,639	767	2,406

Source – Primary Survey (2017)

4. Profile of Freight Handling Areas

Four major locations are used for handling the freight traffic in Udaipur, especially the inter-city freight, namely –

- Truck Terminal at Pratap Nagar
- Truck Terminal at Balicha
- Rana Pratap Railway Station
- Inland Container Depot (ICD) at Khemli Railway Station

4.1. Truck Terminal – Pratap Nagar

Located in the eastern periphery of UCA of Udaipur, the truck terminal at Pratap Nagar is a 9.5-hectare large dedicated space for freight handling, which is managed by a private cooperative association of about 120 transport operators that use it. It has three main sub-divisions – (1). Space for Parking of Trucks within the terminal, (2). Commercial Areas and (3). Godowns/Warehouses. It is a well-planned area with segregated spaces for handling and storage of goods and parking of trucks. Apart from these, it has many other facilities like offices, godowns & loading/unloading areas for transport operators, Services like petrol pump, repair shops, etc., Public and Semi-public areas like post office, health facility etc., Idle-parking, circulation space etc.

Major commodities include construction materials, clothing and utensils, plastic, agricultural goods, chemicals, electronics, pharmaceuticals, stationary, etc. The terminal has a storage capacity of 3,500 tonnes and average dwell time for the goods is about 2.5 days. This higher capacity allows the facility to handle an average daily inflow of 1,950 tonnes of freight per day and an average daily outflow of 1,300 tonnes of freight per day. Also, the terminal has a capacity to handle a fleet of 800 trucks and 150 LCVs of the transport operators. It employs about 2,500 people out of which, 1,100 are drivers. For using the facility, the transport operators need to pay charges as follows (Table 9.) –

Table 9. Charges incurred at the Truck Terminal in Pratap Nagar, Udaipur

S. No.	Type of Charge	Amount
1.	<u>Entry Charge</u>	
	Trucks from Rajasthan	Rs. 1,500 per Truck
	Truck from Gujrat & Madhya Pradesh	Rs. 2,100 per Truck
	Trucks from other states	Rs. 2,500 per Truck
2.	Loading / Unloading	Rs. 70 – 100 per Tonne
3.	Weighing of Freight	Rs. 50 – 100 per Tonne

Source – *Primary Survey (2017)*

There are some problems associated with the terminal too. There is a Common Entry/Exit from a single gate and so, at times, it becomes very congested and so, difficult to get into the terminal due to long queue of vehicles. Also, the primary survey revealed that having just a single warehousing location on the periphery of the city is inconvenient and intermediate locations within the city are required which might reduce the turnaround time.

4.2. Truck Terminal at Balicha Bypass

Located in the southern periphery of UCA of Udaipur, the truck terminal at Balicha bypass is a huge 60-hectare large, government managed dedicated space for freight handling, which has been recently established in 2014. It was intended to ease the huge traffic that comes at the Truck terminal on Pratap Nagar by shifting majority of transport operators to this site. It offers a locational advantage too due to its close proximity with railway station, saras dairy, Agricultural Produce Market, etc. But at present, there are only about 43 transport operators in this terminal as the site has not yet been fully acquired and developed. Most of its area is occupied with people living there. It is handling an average daily traffic of about 20 MAVs, 150 HCVs and 267 LCVs, which is way less than the actual capacity that it can handle when fully developed. Major commodities which are handled here include Chemicals, Electronics, Plastics, Clothes, Paper products, Metals, etc. It is estimated that about 1,754 tonnes of freight is handled every day in this terminal. Primary survey reveals that due to poor condition of roads and lack of facilities, most operators are not willing to shift here.

4.3. Rana Pratap Railway Station

The Rana Pratap Railway Station is about 6 kilometers away from Udaipur Railway Station and has a facility of 3.3-hectares which is meant mostly for handling freight that arrives or departs by railway. Major areas which the station includes container loading and unloading areas and cargo stocking areas. When inbound rakes arrive, tractors take off the rakes and keep them at the halting place for it to be transported into the city and for outbound ones, stacking of rakes is done on site, 2 hours before they are loaded and transported.

About 285 tonnes of inbound freight arrives daily on this facility which majorly include food grains which are imported in Udaipur from the states of Punjab, Madhya Pradesh and Haryana. From here, it goes to Pratap Nagar Transport Nagar for private retail distribution and godowns of Food Corporation of India for government ration and PDS distribution centres using LCVs. The outbound freight majorly includes about 750 tonnes of minerals and marble based by-products to various states of the country. This freight mainly originates from Mewar Industrial Area in Udaipur and is transported to the railway station using 2-axle trucks and then, they are loaded on to the wagons for regional transportation.

4.4. Inland Container Depot (ICD) at Khemli Railway Station

Inaugurated in April 2017 by Container Corporation of India (CONCOR), this ICD is currently functioning as domestic terminal establishing empty containers for goods movement. The main reason behind the construction of this facility was to connect Ahmedabad, by the time Delhi-Mumbai Industrial Corridor (DMIC) will be start functioning. It has an area of 10 hectares and a proposed storage capacity of 25,000 TEU.

5. Supply Chain Characteristics of Principal Commodities

The supply chain of all the major commodities in Udaipur has been tracked through extensive primary surveys and their characteristics have been discussed.

5.1. Food Grains

About 7,063 tonnes of food grains are procured every day in Udaipur. These are grown in Udaipur as well as nearby areas like Jharol, Khelwada, etc. but majority of it comes from other parts of Rajasthan like Jaipur and Alwar, and other states like Punjab, Haryana, Delhi, etc. After procurement, about 6,401 tonnes are transported to truck terminal at Pratap Nagar, either by road based modes or by railways in which, first they are unloaded at Rana Pratap Railway Station and from there, they are transported to truck terminal by trucks. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 200 kilometers and so, the tonne kilometer comes out to be around 29.8 lakh kilometers. From the terminal, as part of Tier – 2 distribution, they are mostly transported to Dhan Market and Agricultural Produce Market by Trucks and LCVs and further to retail markets using LCVs, NMT or through Head Loads, covering a weighted average distance of 7.2 kilometers and 2,282 tonne kilometers. About 662 tonnes of grains are also transported to Dhan Market and Agricultural Produce Market directly after procurement using trucks or railway. This complete supply chain accounts for 17% of the total cost of transportation of urban freight in Udaipur.

5.2. Fruits and Vegetables

About 4,536 tonnes of fruits and vegetables are procured every day in Udaipur. Majority of these are grown in Udaipur as well as nearby areas like Gogund, Jharol, Kalisia, Markanpur, etc. Some are also procured from other parts of Rajasthan as well as, other states like Gujrat, Madhya Pradesh, Delhi, Uttar Pradesh, Maharashtra, Karnataka and Andhra Pradesh. After procurement, about 4,001 tonnes are transported to truck terminal at Pratap Nagar, either by road based modes or by railways in which, first they are unloaded at Rana Pratap Railway Station and from there, they are transported to truck terminal by trucks. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 178 kilometers and so, the tonne kilometer comes out to be around 8 lakh kilometers. From the

terminal, as part of Tier – 2 distribution, they are mostly transported to Dhan Market, Agricultural Produce Market and Mukherjee Chowk, by Trucks and LCVs and further to retail markets using LCVs, NMT or through Head Loads, covering a weighted average distance of 5.4 kilometers. About 535 tonnes of grains are also transported to Dhan Market and Agricultural Produce Market directly after procurement using trucks or railway. This complete supply chain accounts for 22% of the total cost of transportation of urban freight in Udaipur.

5.3. Textile

About 5,176 tonnes of textiles are procured every day in Udaipur. Majority of these come from Surat, Delhi, Kolkata and Ahmedabad. After procurement, about 4,886 tonnes are transported to truck terminals at Pratap Nagar and Balicha bypass, by road based modes like HCVs, MAVs, etc. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 346 kilometers and so, the tonne kilometer comes out to be around 17.9 lakh kilometers. From the terminals, as part of Tier – 2 distribution, they are mostly transported to wholesale markets like Hathipol, Dhan Market, Bapu Bazar, Ashwini Bazar, Gulabh Bagh and Panchwati, by LCVs and further to retail markets using LCVs, NMT or through Head Loads, covering a weighted average distance of 5 kilometers. About 290 tonnes of grains are also transported to the mentioned wholesale markets, directly after procurement using road based modes. This complete supply chain accounts for 19% of the total cost of transportation of urban freight in Udaipur.

5.4. Dairy / Poultry

About 3,839 tonnes of Dairy and Poultry are procured every day in Udaipur. Majority of these come from village clusters under Saras Dairy Co-operative as well as Jodhpur dairy farms. After procurement, about 3,201 tonnes are transported either to Saras Dairy or other competitors and about 1,686 tonnes are transported directly to retailers, by road based modes like HCVs, MAVs, Insulated Trucks, etc. etc. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 58 kilometers and so, the tonne kilometer comes out to be around 2.2 lakh kilometers. About 638 tonnes are also transported to markets at Chetak Circle, Hiran Magri, etc. From such intermediate locations, as part of Tier – 2 distribution, they are sent to Booths and shops in retail markets using Insulated Trucks, LCVs, NMT or through Head Loads, covering a weighted average distance of 6 kilometers. This complete supply chain accounts for 21% of the total cost of transportation of urban freight in Udaipur.

5.5. Handicrafts

About 4,223 tonnes of Handicraft items are procured every day in Udaipur. Majority of these come from Sukher and Alwar. After procurement, about 4,001 tonnes are transported to truck terminals at Pratap Nagar and Balicha bypass, by road based modes like Trucks and LCVs. About 2,712 tonnes are directly exported. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 112 kilometers and so, the tonne kilometer comes out to be around 4.7 lakh kilometers. From the terminals, as part of Tier – 2 distribution, they are mostly transported to Sukher Marble Market, Raj Nagar Marble Market, Bhuwana, Thokar Chowraha and Salumbar Road, by Trucks and LCVs and further to retail markets in Sukher, Bhuwana, Hathipole, etc., using LCVs, NMT or through Head Loads, covering a weighted average distance of 5.4 kilometers. About 222 tonnes of grains are also transported to wholesale markets directly after procurement using trucks or LCVs. This complete supply chain accounts for 26% of the total cost of transportation of urban freight in Udaipur.

5.6. Paper and Plastic

About 2,976 tonnes of Paper and Plastic items are procured every day in Udaipur. Majority of these come from Chittorgarh, Surat, Ahmedabad, Gandhinagar and Delhi. After procurement, about 2,400 tonnes are transported to truck terminals at Pratap Nagar and Balicha bypass, by road based modes like Trucks and LCVs. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 58 kilometers and so, the tonne kilometer comes out to be around 1.7 lakh kilometers. From the terminals, as part of Tier – 2 distribution, they are

mostly transported to Chetak Circle, Sarawati Marg, Hiran Magri, etc. by Trucks and LCVs and further to retail markets in walled city and other areas, using Trucks and LCVs, covering a weighted average distance of 5.6 kilometers. About 576 tonnes of grains are also transported to wholesale markets directly after procurement using trucks. This complete supply chain accounts for 21% of the total cost of transportation of urban freight in Udaipur.

5.7. Sports Equipment

About 610 tonnes of Sports Equipment items are procured every day in Udaipur. Majority of these come from Chittorgarh, Surat, Ahmedabad, Gandhinagar and Delhi. After procurement, about 400 tonnes are transported to truck terminals at Pratap Nagar and Balicha bypass, by LCVs. In this Tier -1 distribution, the commodity is transported over a weighted average distance of 468 kilometers and so, the tonne kilometer comes out to be around 2.8 lakh kilometers. From the terminals, as part of Tier – 2 distribution, they are mostly transported to Bapu Bazar and Hathipole by Trucks and LCVs and further to retail markets throughout the city, using LCVs, covering a weighted average distance of 7 kilometers. About 210 tonnes of grains are also transported to wholesale markets directly after procurement using trucks. This complete supply chain accounts for 19% of the total cost of transportation of urban freight in Udaipur.

5.8. Drinking Water Bottles

About 1,921 tonnes of bottled water is distributed every day in the city out of which, 800 tonnes are distributed to nearby villages and the remaining 1,121 are transported to the shops in retail markets throughout the city of Udaipur.

6. Freight Traffic Characteristics and Travel Patterns in Udaipur

The Urban Control Area (UCA) of Udaipur has a total Road Network of length 822 kilometers (*OSM, 2017*). The operation of goods carrying vehicles on this network is bound to time restrictions. The heavy vehicles are not allowed to enter the Municipal Council Area between 6AM to 11PM and only Light Commercial Vehicles (LCVs) can operate in those hours. So, municipal area doesn't have much congestion except for the walled city and nearby areas which are commercial hubs and relatively don't have much road space. On the other hand, all kinds of vehicles are allowed on the roads outside the municipal limits.

6.1. Traffic Characteristics at Outer Cordon Locations

As per the Primary Survey conducted at three outer cordon locations in Udaipur – Amberi, Debari and Balicha, and the expansion factor adopted from the Low Carbon Mobility Plan for Udaipur, it has been estimated that an Average Daily Traffic (ADT) of about 63,741 vehicles are handled at these locations. Directional flow indicates more volume of traffic to be outbound (57% on an average) than inbound (43%). Daberi accounts for maximum average daily traffic (nearly 50% of total ADT) among the three locations. It connects Udaipur to cities like Chittorgarh, Neemuch, Kota, etc. in east of Rajasthan. The freight carrying vehicles account for 37% of the total traffic at outer cordon locations. The share of freight traffic in ADT varies from 27% to 51%, with Balicha having a maximum share (51%). Out of all the freight carrying modes, 3-Axle trucks and Multi Axle Vehicles (MAVs) together account for 61% of the total freight traffic related Passenger Car Units (PCUs) at outer cordon (Table 10).

Table 10. Average Daily Traffic (ADT) of Freight Carrying Vehicles at Outer Cordon Locations

S. No.	Location	Total Freight Traffic	Share (%)	LCV (3 Wheeler)		LCV (4 Wheeler)		2-Axle Trucks		3-Axle Trucks		MAVs		Tractors & Trailers		Total PCU
				No.	PCU	No.	PCU	No.	PCU	No.	PCU	No.	PCU	No.	PCU	
1.	Amberi	2892	12%	107	150	214	428	536	1179	1071	4284	750	1500	214	856	8397
2.	Debari	9753	41%	315	441	944	1888	1573	3461	3775	15100	2831	5662	315	1260	27812
3.	Balicha	11001	47%	647	906	1510	3020	1941	4270	3236	12944	2804	5608	863	3452	30200
Total		23646	100%	1069	1497	2668	5336	4050	8910	8082	32328	6385	12770	1392	5568	66409

Source – Primary Survey and Static PCU values have been adopted from IRC-106: 1990

The study also accounted for the hourly variation of traffic, with daytime variation being recorded through primary survey and daytime variation adopted from the secondary data (IL&FS, 2017). Share of the volumes in the day and night has been shown (Table 11).

Table 11. Variation of Traffic Volumes of Freight Carrying Vehicles at Day and Night on Outer Cordon Locations

Time Interval	Share (%)	Locations			Total	
		Amberi	Daberi	Balicha		
Day	06:00 to 14:00	35.3%	1021	3443	3883	8347
	14:00 to 22:00	39.5%	1142	3852	4345	9340
Sub - Total	74.8%	2163	7295	8229	17687	
Night	22:00 to 06:00	25.2%	729	2458	2772	5959
Total	100%	2892	9753	11001	23646	

Source – (IL&FS, 2017)

75% of the freight traffic volume recorded at the outer locations was during daytime and between the time duration of 06:00 – 22:00. The reason for the higher traffic during daytime is the high share of by-passable traffic which has been discussed further in the study.

6.2. Traffic Characteristics at Market Locations

As per the Primary Survey conducted at four market locations in Udaipur – Chetak Circle, Court Chowk, Surajpole and Udaipole, and the expansion factor adopted from the Low Carbon Mobility Plan for Udaipur, it has been estimated that an Average Daily Traffic (ADT) of about 3,12,869 vehicles are handled at these locations. Directional flow indicates more volume of traffic to be outbound (62% on an average) than inbound (32%). Surajpole accounts for maximum average daily traffic (nearly 33% of total ADT) among the four locations. It is the commercial center of the city and attracts large number of trips every day. However, the freight carrying vehicles account only 7.8% of the total traffic at market locations. The share of freight traffic in ADT is nearly similar, ranging from 7% to 8.5%, with Court Chowk having a maximum share (8.5%). Out of all the freight carrying modes, 3-wheeler and 4-wheeler LCVs together account for 85% of the total freight traffic related Passenger Car Units (PCUs) at market locations (Table 12).

Table 12. Average Daily Traffic (ADT) of Freight Carrying Vehicles at Market Locations

S. No.	Location	Total Freight Traffic	Share (%)	LCV (3 Wheeler)		LCV (4 Wheeler)		2-Axle Trucks		Tractor & Trailer		Hand Cart		Total PCU
				No.	PCU	No.	PCU	No.	PCU	No.	PCU	No.	PCU	
1.	Chetak Circle	5306	22%	1516	2122	2274	4548	190	417	190	758	1137	2274	10119
2.	Court Chowk	5784	24%	2050	2869	3074	6148	171	376	171	684	319	638	10715
3.	Surajpole	8320	34%	2080	2912	5200	10400	260	572	260	1040	520	1040	15964
4.	Udaipole	4857	20%	1619	2267	2753	5505	162	356	162	648	162	324	9100
Total		24268	100%	7265	10170	13301	26601	783	1722	783	3130	2138	4276	45899

Source – Primary Survey and Static PCU values have been adopted from IRC-106: 1990

Just like the Outer Cordon locations, the hourly variation of traffic at market location have also been recorded. However, Data for Hourly Variation of Freight Traffic at Mid-Block has not been reported in any secondary source, therefore only primary data has been considered and. It shows that freight traffic is maximum during early morning hours, dips during noon and again rises in the evening.

6.3. Freight Travel Patterns and flow of Tonnage

The freight travel pattern and characteristics have been again studied at two levels like freight traffic characteristics for Udaipur city. The first level is inter-city (regional movement of freight) and the second level is Intra-City (freight movement within freight generating areas and freight handling areas in the city).

The primary surveys conducted and secondary data collected reveal that majority of the interaction of Udaipur for freight import and export is within its own state of Rajasthan and surrounding states of Punjab, Haryana, Gujarat, Madhya Pradesh, Maharashtra and UT of Delhi. The Origin-Destination Surveys conducted for freight carrying vehicles at the outer cordon revealed that 73% of the vehicles at outer cordon constitute through traffic whereas only 27% of the freight traffic is destined, i.e. either to/from Udaipur (Table 13).

Table 13. Inter-City Estimated Vehicular Trips of Freight at Outer Cordon

Direction	Amberli Bypass	Daberi Bypass	Balicha Bypass	Total Vehicles per Day	Share (%age)
External – Internal	333	1365	1815	3513	16%
Internal – External	289	1122	1320	2731	11%
External – External	2270	7266	7866	17402	73%
Total	2892	9753	11001	23646	100%

Source – Primary Survey

Tonnage flow at both the levels (inter and intra-city) was estimated using the average payload per loaded vehicle and number of vehicular trips mode wise at all the survey locations. Tonnage flow estimation at the Inter-City level has been shown (Table 14).

Table 14. Inter-City Freight Volume (Tonnage) Estimation

Mode	LCV (3W)	LCV (4W)	2 Axle Truck	3 Axle Truck	MAV	Tractor Trailer	Total	
In-bound	Total Vehicles	488	1217	1817	3600	2862	630	10614
	Empty Vehicles	38%	34%	45%	49%	53%	65%	
	Total Loaded Vehicles	303	803	999	1836	1345	221	5507
	Avg. Payload	0.18	1.4	6	9	12	3	
	Total Tonnage Inbound	54	1125	5996	16524	16142	662	40502
Out-bound	Total Vehicles	581	1451	2233	4482	3523	762	13032
	Empty Vehicles	14%	28%	52%	47%	56%	74%	
	Total Loaded Vehicles	500	1045	1072	2375	1550	198	
	Avg. Payload	0.14	1.1	4.5	7.8	9	5	
	Total Tonnage Outbound	70	1149	4823	18529	13951	991	39513
Total Tonnage Flow per Day	124	2274	10819	35053	30093	1652	80015	

Source – Primary Survey

Based on the total tonnage flow estimation and the vehicular trips pattern shown in the above two sub-sections, the tonnage flow pattern was estimated. It revealed that 15% of the tonnage was in bound (i.e. External to Internal regions) and 12% of the tonnage was outbound (internal to external regions), leaving the rest of 73% of the tonnage to be through flow. The details of tonnage flow at each location have been given below –

Table 15. Estimated Tonnage Flow at Outer Cordon

Direction	Amberi Bypass	Daberi Bypass	Balicha Bypass	Total Ton per Day	Share (%)
External – Internal	1132	4615	6139	11886	15%
Internal – External	984	3791	4465	9240	12%
External – External	7726	24560	26603	58889	73%
Total	9842	32966	37207	80015	100%

Source – Primary Survey

The major freight generating and handling areas in the Udaipur have already been discussed in the earlier sections. The Origin and Destination surveys conducted at the mid-block locations also reveal the same pattern of freight travel demand within the city. These revealed that 66% of the freight vehicular movement is within the Municipal Corporation Boundary of Udaipur city. The rest of the 34% vehicular movement is between Udaipur Municipal Corporation Area and Urban Control Area of Udaipur as demarcated by the Master Plan (Table 16).

Table 16. Intra-City Estimated Vehicular Trips of Freight at Mid-block

Direction	Chetak Circle	Court Chowk	Surajpole	Udaipole	Total Vehicles per Day	Share (%)
External – Internal	1327	1388	1664	1166	5545	20%
Internal – External	743	579	749	631	2702	14%
Internal - Internal	3237	3818	5907	3060	16022	66%
Total	5306	5785	8320	4857	24268	100%

Source – Primary Survey

Tonnage flow at both the levels (inter and intra-city) was estimated using the average payload per loaded vehicle and number of vehicular trips mode wise at all the survey locations. Tonnage flow estimation at the Intra-City level has been shown in the table below –

Table 17. Intra-City Freight Volume (Tonnage) Estimation

Mode	LCV (3W)	LCV (4W)	2 Axle Truck	Tractor Trailer	Hand Cart	Total	
In-bound	Total Vehicles	2772	5234	307	307	858	9478
	Empty Vehicles	38%	44%	70%	65%	10%	
	Total Loaded Vehicles	1719	2931	92	107	772	5621
	Avg. Payload	0.14	0.85	5.5	2.4	0.1	
Out-bound	Total Tonnage Inbound	241	2491	507	258	77	3574
	Total Vehicles	4493	8066	476	476	1280	14791
	Empty Vehicles	24%	38%	60%	55%	6%	
	Total Loaded Vehicles	3415	5001	190	214	1203	10023
Avg. Payload	0.14	0.9	2.5	1.8	0.1		
Total Tonnage Outbound	478	4501	476	386	120	5961	
Total Tonnage Flow per Day	719	6992	983	643	198	9534	

Source – Primary Survey

Based on the total tonnage flow estimation and the vehicular trips pattern shown in the above two sub-sections, the tonnage flow pattern was estimated. It revealed that 23% of the tonnage was in bound (i.e. External to Internal regions) and 11% of the tonnage was outbound (internal to external regions), leaving the rest of 66% of the tonnage to be internal flow (Table 18).

Table 18. Estimated Tonnage Flow at Mid-block

Direction	Chetak Circle	Court Chowk	Surajpole	Udaipole	Total Ton per Day	Share (%)
External – Internal	524	549	648	458	2180	23%
Internal – External	294	229	292	248	1062	11%
Internal - Internal	1280	1510	2302	1201	6293	66%
Total	2098	2288	3242	1907	9534	100%

Source – Primary Survey

6.4. Location Wise Freight Volume (Tonnage) Flow Pattern within Udaipur UCA

Freight volume flow was also analyzed through the data collected at establishment level at freight generating and freight handling areas. This data along with the OD data collected was analyzed to form the freight volume flow pattern within the city of Udaipur, i.e. how the goods flow in the city. The following (Table 19) provides an overall picture of the flow of goods in the city between freight generating, freight handling and consumption areas.

Table 19. Matrix showing movement of goods (Tonnage) in Udaipur

Location	Walled City	Within UCA	Krishi Mandi	Saras Dairy	Transport Nagar	Sukher Marble Mandi	Industries	External Region	Total
Walled City	0	1105	0	0	899	1	1105	1314	4423
Within UCA	621	0	0	0	691	138	829	985	3264
Krishi Mandi	1189	447	0	0	138	0	0	1404	3179
Saras Dairy	12	17	0	0	40	0	0	100	169
Transport Nagar	69	69	0	0	0	138	691	876	1842
Sukher Mandi	1	66	0	0	138	0	0	767	973
Industries	275	26	0	0	829	0	0	3334	4463
External Region	998	391	3400	196	1888	1157	4265	0	12294
Total	3166	2122	3400	196	4623	1433	6889	8778	30660

Source – Primary Survey

Based on above table showing movement of goods, the total freight handled at each location was computed as shown in the table below –

Table 20. Total estimated freight handled in Udaipur

Location	Internal – Internal	External – Internal	Internal – External	Total	Share (%)
Walled City	3109	998	1314	5421	18%
Within UCA	2279	391	985	3655	12%
Mandi	1775	196	2299	4269	14%
Saras Dairy	69	196	100	364	01%
Transport Nagar	967	1888	876	3730	12%
Sukher Marble Mandi	206	1957	767	2929	10%
Industries	1130	6261	2901	10291	34%
Total	9534	11886	9240	30660	100%

Source – Primary Survey

Industries account for maximum share of tonnage handled in the city, because of regional goods movement. Within Udaipur city limits, Walled City Market accounts for maximum share of tonnage handled per day.

6.5. Cumulative Freight Travel Pattern at Inter and Intra-City Level

The individual analysis of inter-city and intra-city freight travel pattern has been put together to create a comprehensive picture of overall freight travel pattern in the city of Udaipur (Table 21).

Table 21. Cumulative Vehicular Movement and Freight Volume Flow in Udaipur

Direction	Vehicle Trips per Day	Tonnage Flow per Day	Tonnage Share (%)
Internal – Internal (I-I)	24268	9534	11%
External – Internal (E-I)	3513	11886	13%
Internal – External (I-E)	2731	9240	10%
External – External (E-E)	17402	58889	66%

Total	47914	89549	100%
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Source – Primary Survey

This depicts that through tonnage flow (E-E) accounted for 66% of the total freight volume whereas 13% share was of External – Internal, 10% of Internal – External and 11% of Internal – Internal. So, a total of 89,549 tonnes of commodities flow between various areas in Udaipur

7. Freight Demand Modelling for Base Year (2017)

In order to clearly understand this scenario, the entire freight traffic of UCA of Udaipur has been simulated in software using 4-stage modelling for 24 Hours, considering the hourly variation of traffic. For that purpose, the network has been prepared in Geographic Information System (GIS) based software called ArcGIS and the attributes like number of lanes from primary Road Inventory Survey, Running Speed from primary Speed and Delay Survey and Lane Capacity in terms of Passenger Car Units per Hour (Table 22), taken from the guidelines of Indian Road Congress have been considered.

Table 22. Total Design Service Volumes for Different Categories of Roads

S. No.	Type of Carriageway	Capacity (PCUs/Hr)			
		Arterial	Sub-Arterial	Collector	Local
1	2-Lane (One Way)	2400	1900	1400	1200
2	2-Lane (Two Way)	1500	1200	900	1200
3	3-Lane (One Way)	3600	2900	2200	-
4	4-Lane Undivided (Two-Way)	3000	2400	1800	-
5	4-Lane Divided (Two Way)	3600	2900	-	-
6	6-Lane Undivided (Two Way)	4800	3800	-	-
7	6-Lane Divided (Two Way)	5400	4300	-	-

Source – IRC-106-1990

This processed network, along with 35 Traffic Analysis Zones (TAZ), delineated on the basis of homogeneous character of commercial & industrial areas, have then been imported into the Transport Modelling software – PTV Visum. The 4-stage modelling process has been executed in mixed traffic, using the demand matrices and Trip Length Frequency Distribution (TLFD) which have been estimated using the Origin and Destination Surveys. This too has been done separately for Intra-city and Inter-city movements. The assignment has been done on to the network and it has been observed that after assigning the vehicles on the network, most of the regional roads were showing huge traffic as compared to Inter-city roads.

Further, the mode-wise assignment on various links, when multiplied by the mode-wise average payload, obtained from the primary survey gave the values for the assigned tonnage of various commodities on the network (Figure 1).

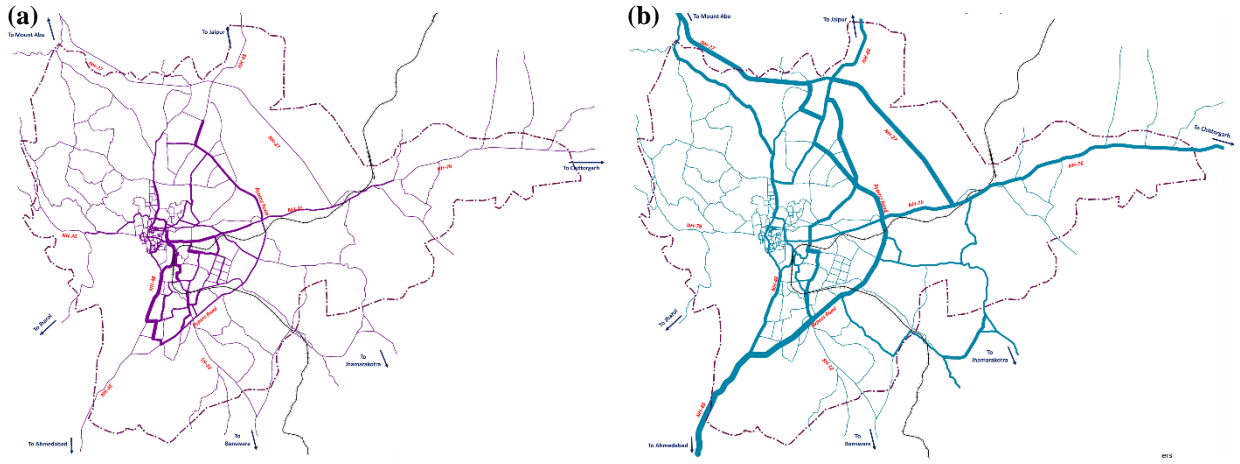


Figure 1. (a) Intra-City Traffic Assignment (b) Inter-city Traffic Assignment

It is important to note here that the model has been validated by comparing the assigned volumes at the outer-cordon and market locations with the actual ground counts and the variations have been accepted within the range of (+/-) 15%. For the locations where the variation was more than that, re-calibration of the model was done in the software to bring it within the range.

8. Evaluation of Key Performance Indicators (KPIs)

Many results have been derived from this assignment, as well as primary surveys conducted in UCA of Udaipur (Table 23.), and they have been summarized in the form of Key Performance Indicators (KPIs).

Table 23. Values of Key Performance Indicators obtained from Traffic Assignment

Type of Parameter	Key Performance Indicator	Value
Freight Generation	Ton per Capita per Day	0.013 (13 kg)
	Ton per Hectare (Gross: Developed Area)	1.6
	Ton per Hectare (Net: Commercial and Industrial Areas)	10.6
Freight Distribution	Average Haulage Length (km)	6.3
	Average Payload (Gross: Empty Vehicle Share included) (Ton/Vehicle)	0.56
	Average Payload (Loaded Vehicles) (Ton/Vehicle)	1.32
	Average In-Vehicle Time per Ton (Hours)	0.5
	Average Out-Vehicle Time per Ton (Hours)	1.5
	Average Total Distribution Time per Ton (Hours)	2
	Total Vehicle Kilometer Travelled per Day (km)	1,47,404

	Total Ton Kilometer Travelled per Day (Ton Km)	11,95,24,044
	Average Ton Km per Day per Vehicle	3619
	Average Distribution Cost per Ton Kilometer (INR)	103
	Total Freight Vehicle Hours per Day	6306
Freight Network & Modes	Share of Freight Network (%age)	46
	Average Vehicle Capacity Utilization per Trip (%age)	36
Freight Handling Efficiency	Number of Major Handling Facilities	4
	Freight Handling Capacity	15,000
	Dedicated Fleet Size for Handling	4800
	Freight Handling Charges	1500
Energy Consumption	Total Fuel Consumption per Day (Litres per Day)	31,516
	Average Fuel Consumption per Vehicle per 100 Km (Litres)	19.8
	Freight Fuel Consumption / Total Transport Fuel Consumption	38
Air Pollution (Note: Emission Standards From CPCB)	Total Vehicle Emissions per Day (Ton / Day / Vehicle)	1.37
	CO Emissions (Ton / Day / vehicle)	0.47
	HC+NOx Emissions (Ton / Day / Vehicle) (Only for 3W LCV)	0.06
	HC Emissions (Ton / Day / vehicle)	0.11
	NOx Emissions (Ton / Day / vehicle)	0.71
	PM(g/km) Emissions (Ton / day / vehicle)	0.02
	Freight Pollution / Total Transport Pollution	29

Source – Primary Surveys and Software Simulation

With the increase in population, there will also be an increase in the urban freight. It is estimated that by the year 2027, the population of UCA of Udaipur will increase to about 11 lakhs and it will then be a million plus city (SPA, 2017). This will result in 1.5 times increase urban freight and the city would have to handle 1,39,545 tonnes of freight of various commodities which would create huge challenges. The already congested highways will be completely choked due to the addition of more freight carriers and operations would become nearly impossible. The intra-city freight distribution will also face challenges because due to increased tonnage, either the fleets size of LCVs would be increased resulting into congestion or the number of trips would increase resulting into more vehicle kilometers travelled. Both will contribute to air pollution. In order to cope with them, innovative practices and solutions will be required along with a relevant freight policy.

9. Conclusion

At present, the Urban Control Area of Udaipur gets a flow of about 89,549 tonnes of freight volume daily, that is, about 13 kilograms of freight generation per capita per day. Compared to the freight that comes in, the handling is not very efficient as there is only one fully functional terminal at Pratap Nagar and that too is usually congested and so, delays occur. The terminal at Balicha is not fully operational. Also, there is a lack of an intermediate handling facility near the core city area and so, the smaller freight carrying vehicles like LCVs usually have to make multiple trips to terminals, godowns, warehouses, industries, markets, etc. Although there are some initiatives in the Udaipur Master

Plan – 2031 to handle this flow through dedicated facilities like truck terminals, they have been proposed on Ad-hoc basis and without the knowledge of Urban Freight Logistics and Supply Chains in the city. The basic requirements for an efficient and sustainable management of urban freight would include –

- Coherent policies on the transportation sector, economy and urban development
- Innovative and well-thought measures
- Knowledge of technologies involved and their utility
- Clearly defined and properly assigned institutional responsibilities
- Adequate legal framework and organizational structure
- Functional mechanisms like vehicle licensing and road taxation
- A sense of civic compliance amongst the parties involved.

10. Acknowledgement

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