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IMPLEMENTING CIRCULAR ECONOMY CONCEPTS FOR SUSTAINABLE URBAN FREIGHT TRANSPORT: CASE OF TEXTILE MANUFACTURING SUPPLY CHAIN

Bhavesh Dhonde
Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, Pin 395 007, India, bhaveshdhonde@gmail.com (corresponding author)
Chetan R. Patel
Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, Pin 395 007, India, chetanrpatel@rediffmail.com

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Abstract: Rapid industrialization and mass urbanization have generated a challenging situation for the city's planners and managers to maintain a balance between economic development and a sustainable environment for its inhabitants. Circular economy concepts can offer a unique opportunity to decouple growth from resource requirements. At the core of the circular economy, is the proposition of complete elimination of waste – i.e. waste not in its traditional sense, but any form of underutilization of assets and resources. A case study of the textile manufacturing industry in Surat, India is taken to compare the performances of traditional supply chain processes and the advantages of adopting circular economy concepts. Temporal sprawl of the textile industry is used to find the changes in trip lengths of urban freight trips over the last two decades. For estimating freight trips volume and patterns, roadside interviews of freight vehicles and establishment surveys of manufacturing and trading units were conducted. Overall urban freight transport contribution from the textile industry is estimated by modelling field data. Organized trip planning and optimized utilization of payload capacities can reduce vehicular emission generated from commercial goods movement in the textile industry to $2/3^{rd}$ of its current levels. The paper asserts reinforces that the integration of circular economy principles with supply chain processes is beneficial from sustainability as well as a business point of view. The congestion mitigation due to the reduced number of trips offers a further reduction in the overall traffic emissions due to better traffic flows on the city's road network.

1 Introduction

Circular economy (CE) is the representation of a continuous cycle that cautiously utilizes natural capital, optimizes resource yields, and minimizes system risks by managing stocks and renewable flows. According to CE Principles, any kind of limited resources should follow 3Rs, i.e. reduce, reuse and renew [1], while renewable resources should follow the 6Rs, i.e. reuse, recycle, redesign, remanufacture, reduce, recover [2]. Building a CE environment needs coherent change in consumer behaviour, governmental policies, and business practices. Such a transition is complex and requires simultaneous changes in various sub-systems, such as energy, logistics, and financial sub-systems. In different parts of the world, the concept of CE has evolved differently based on their cultural, social, and political systems [3]. For instance, in the United States and Canada, corporations apply the CE concept to conduct product-level life cycle studies [4], in Europe CE is applied for addressing issues associated with the use of natural resources for sustained economic growth as well as for effective waste management [5]. Some CE related initiatives in South Korea and Japan aims to increase consumers' responsibility for material use and waste [6,7]. In China, the concept of CE is used as a mechanism for profitable product development, technology development, and improving industry management [8].

Post economic liberalization in 1991, India has been experiencing environmental degradation in extreme measures. As the economy struggles with supply-demand issues, faster urbanization is leading to a greater generation of waste. On one hand, there is a need to sustain the industrial growth in our desire to become a developed economy; and on the other hand, it is critical to identify innovative growth models that do not aggravate the existing resource constraints in India. It is estimated that in India, the transport sector emits 258.10 million metric tons of carbon dioxide (CO_2), out of which 94.5% was contributed by road transport alone [9]. The present case study is of Surat city, which is located on the western coast of India in Gujarat state. The city is the 8^{th} most populous with around 4.6 million people [10]. With the decadal growth of over 55%-60% since the last four decades, it is one of the most sought destinations for employment and business opportunities. The city has a very vibrant economy as it is a hub to the diamond and textile industry. Globally, 63% of the textiles produced is through synthetic fibres [11], which are derived from petrochemicals and its production leads to the generation of CO_2 [12]. Surat, located on the western coast of India is also a big manufacturing hub of synthetic textiles. The city is popularly known as the "Synthetic capital of India" for its scale and expertise in the manufacturing of synthetic textiles. Textile manufacturing processes in Surat have a fragmented industry structure leading to several goods movement trips in the city. According to a study, the internal goods movement generated by the textile industry makes around 40% of the total internal goods movement by light commercial vehicles (LCV) [13]. In the present study freight trip generation from the textile industry is estimated and the emission impact of these trips is found.

The city has a very high level of vehicular emissions, especially particulate matter (PM) levels in the areas having industry presence. Almost 38,000 LCV trips made for transport of textile goods are found to be empty due to non-optimized operation generating more than 190 tonnes of CO_2 every day. Empty vehicle trips are also causing unnecessary traffic on city roads thereby reducing the overall efficiency of the network. If the estimated empty LCV trips are optimized by planning complete utilization of payload capacities, 370 thousand vehicle kilometres travel (VKT) can be reduced from the city roads. With reduced use of LCVs owing to optimization, the congestion situation is predicted to mitigate. Vehicular emission, especially Particulate Matter (PM) are found to be in a very high amount in the textile industry clusters, for some areas it is twice the national average and exceeds the permissible limits for a healthy life. The current state of affairs is not sustainable for years to come even after the optimization of empty trips. The use of alternate fuel sources has been extensively promoted in several countries of the world already. In India too, a new policy is taken up by the government to replace petroleum fuel-based vehicles with electric battery vehicles by the year 2030. This initiative can also be implemented for LCV used for short freight trips in cities. Textile freight being lightweight and average trip length under 10 km, diesel engine LCVs can conveniently be replaced by electric LCVs (e-LCV). Also, the use of e-LCV would provide relief to alarming levels of vehicular emission in the highly affected area. The overall ideology is to make the entire goods movement cleaner and eco-friendly for the industry and the city as well. Cleaner urban freight transport would reduce the overall vehicular emission in the form of GHG and CO_2 emitted for every kilometre travelled.

2 Literature review

The circular economy concept has been important, relevant, and applicable for a long time in the manufacturing industry. With depleting levels of natural resources and increasing levels of man-made pollution, the focus of the academic and research community is gradually shifting from the predominant linear growth model of produce, use, and dispose of, to a sustainable and eco-friendly growth model which CE offers. The CE concepts are implemented in several ways by various industries at different times, and hence evidence for the origin of the CE concept is unclear [14]. CE is not a standalone concept, but it is interwoven with various other concepts like industrial symbiosis [15-17]. Some conceptual frameworks for CE proposed by different researchers and institutions are given in Table 1.

Table 1 Concept of circular economy given by different researchers

Year	Conceptual framework for circular economy
2007	Revamping the material flow from linear flow to circular flow; thereby increasing the efficiency of resource utilization and reducing the amount or intensity of emissions [18].
2008	Materials flow in a closed loop of activities with feedback processes, the basic process in which natural resources get transformed into manufactured products thereby generating by-products that can be fed as resources for other industries [19].
2011	Develop a closed system of resource-product-renewed resource, which involves reducing, reusing, and recycling of resources, against a unidirectional system of resource-product-waste [20].
2013	It brings a paradigm shift, used products (waste) used will be repaired, reused, and recycled for other purposes [21].
2014	Shift towards the use of renewable energy sources; eliminate the use of toxic substances and minimization of waste through the superior design of materials, products, systems, and business models. Replacement of the end-of-life concept with restoration [22].
2015	Maximization of in-use resources throughout its life cycle, from sourcing to supply chain, to consumption, to the remaining unusable parts for one function and converted back into a new source for another purpose, thereby reducing the extraction of resources from nature [23].
2016	Decoupling of economic growth from the extraction and consumption of scarce resources with negative footprints and making existing resources productive for as long as possible [24].

Though after a much delay, gradually there is a universal realization that the earth is fragile with its carefully balanced ecosystem and natural resources [25]. There is a fundamental shift in the socio-economic and environmental landscape, technology evolution, population growth, and global awareness regarding the finite nature and rapid depletion of resources. The consumption model, i.e. cradle-to-grave model which involves exploiting the finite resources to create new products and eventually disposing of the used products non-systematically into landfill sites, which lacks sustainability for the future. There is a lot of risks associated with the increasing demand-supply gap due to the growing population, increasing demand for resources, finite nature of resources, and take-make-dispose oriented linear economic model that has led to an interest in the adoption of the cradle-to-cradle model. This cradle-to-cradle approach forms the central idea of the CE model [26,27]. Though a considerable amount of research work is carried out in the area of CE, the majority of it is focusing on the manufacturing and operations phase of any product/ service development. From the 3Rs of CE i.e. reduce, recycle, and renew, [28]; reduce is the components applicable to efficient logistics or supply chain management systems. According to the Circularity Gap Report [29], about 26% of the global carbon dioxide emission is due to transport processes. It is not necessary to recycle or renew the waste or by-products to successfully apply the principles of CE. Reduction in the available resources is also a very way of making the environment sustainable wherever recycle or renew is difficult. There are very limited studies carried out which explore the application of CE in city logistics or freight management.

Urban freight transport (UFT) is a very crucial area for the sustainable existence of cities. Research in UFT has come a long way from early effort started in the 1980s in the US and European Union. Recently, a multistage modelling approach is used that points out the relations existing among city logistics measures, actors, and choice dimensions. It comprises three model sub-systems to estimate the quantity origin-destination (O-D) matrices by transport service type (i.e. retailer driven or wholesaler driven or by a third party carrier), the delivery O-D matrices by delivery period, and the vehicle O-D matrices according to delivery tour departure time and vehicle type [30]. A similar analysis of freight trip attraction (FTA) and its relationship with key features using spatial econometric techniques to assess the role of spatial effects among establishments and the urban environment, where the results show that FTA is better modelled as a non-linear function of employment and other location based variables like floor area and width of connecting road [31]. Bringing urban analysis and spatial studies closer to urban logistics appears to be relevant to tackle last mile issues. A spatial analysis coupled with a logistical approach provide a relevant diagnosis for urban logistics practitioners and local authorities, before the settlement of logistics organizations or new regulations that suit cities' characteristics, assets and constraints carried out comparison of constant freight trip generation (FTG) estimations for three different aggregation levels of activity-based categories to derive different functional forms [32,33]. It is observed that suitable functional form can reduce the need for more disaggregated data, which can reduce the overall cost of collecting data.

From the relevant studies reviewed it has been found that the majority of the researchers have focused only on the freight trip generation aspect in their work, freight distribution and trip assignment is not explored much in research, probably due to the complexity of the supply chain of innumerable goods and service offered. Studies are primarily carried out from the data obtained from transporters dairy, industries, or vehicle surveys. Also, studies have focused on aggregate data of all the freight intensive activities of the city. An exclusive study focusing on trip generation characteristics of the industry and its traffic impact on the city network has probably been an unexplored dimension in the city logistics.

3 Supply chain analysis: Textile industry

Textile is the largest industry in the city employing a million people directly and indirectly. The city has its production facilities specialized in synthetic textiles, having 21 industrial clusters in different parts of the city having more than 25,000 manufacturing (weaving) units, and 513 processing units. Surat exports its textile products to various corners of the country and abroad regularly. The textile industry in the city is highly fragmented with clusters of small production units set up in different corners of the city. Details of production, processing, and trading facilities of the textiles industry are given in Table 2.

Table 2 Details of Textile Industry, Surat

Type of units	Activity	Number of units	Number of Clusters	Approximate area occupied
Powerloom and shuttle-less looms	Weaving of raw fabric	25,000	20	3 million sq. m.
Processing house	Dyeing, printing	400	5	7.43 lacs sq. m.
Value addition works	Embroidery, jari works, lace work etc	11,000	12	1.2 million sq. m.
Trading	Wholesale and retail trading	160 trading complexes	2	3.3 million sq. m.

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The fundamental textiles manufacturing process involves several stages like weaving, dyeing, printing, etc, and requiring goods flow from one place to another for different activities. From the various interactions with industry experts and trading unions, it is observed that the entire textile manufacturing process can be divided into four phases. A diagrammatical representation of the various processes (Figure 1).

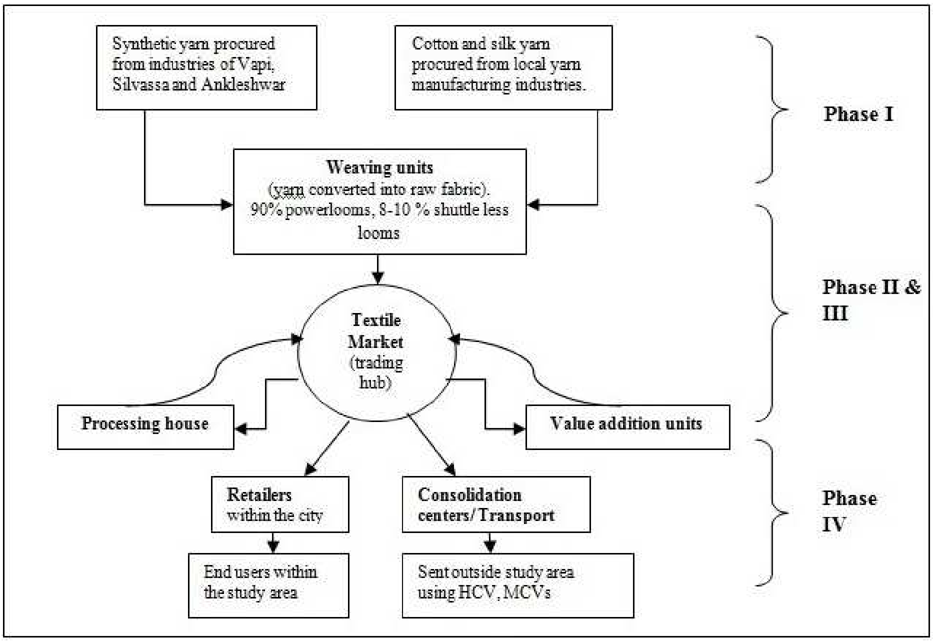

Figure 1 Supply chain of textile manufacturing industry

***Phase 1**:* Raw material procured locally or nearby industrial towns (Vapi, Ankleshwar) reaches Surat in the form of yarn reaches the weaving units (powerlooms)., which is then sent to the textile market for trading or further processing. In this stage, the predominant modes of transport are heavy commercial vehicles (HCV) and medium commercial vehicles (MCV).

Phase 2: The yarn is weaved to produce raw fabric or grey cloth which is sent to the textile market, it undergoes various initial quality checks there. Here the transportation of the processed fabric takes place through LCVs.

***Phase 3**:* Raw fabric is then sent to the processors for dyeing and printing activities. Then again, the processed fabric is sent to the textile market for final quality checks. Freight is moved using LCVs here. The processed fabric from the textile market is sent to various small-scale value addition units. Since the value addition units have a very small quantity of goods transactions, it is generally carried using two-wheelers or passenger three-wheelers also.

Phase 4: In this stage, the processed and value-added fabric, after undergoing physical quality checks at the textile market, is dispatched to the consolidation centre. From the consolidation centre, the finished textile is distributed outside the study area via HCVs and MCVs. As there are a large number of units for each phase of production and traders involved, a lot of trading activity of goods takes place in the city leading to frequent traffic jams and congestion (Figure 2).

Figure 2 Traffic condition at Surat's textile market area

The city has a very well developed market along with it major arterial road (ring road) for trading in textile goods, the market covers an approximate area of 3 square kilometres and has more than 140 building complexes housing approximately 60,000 traders engaged in the textile business. The textile industry of the city is witnessing continuous sprawl in its manufacturing and market facilities over the last three decades. Figure 3 shows the expansion of the textile market area of the city from the year 2000 to 2018.

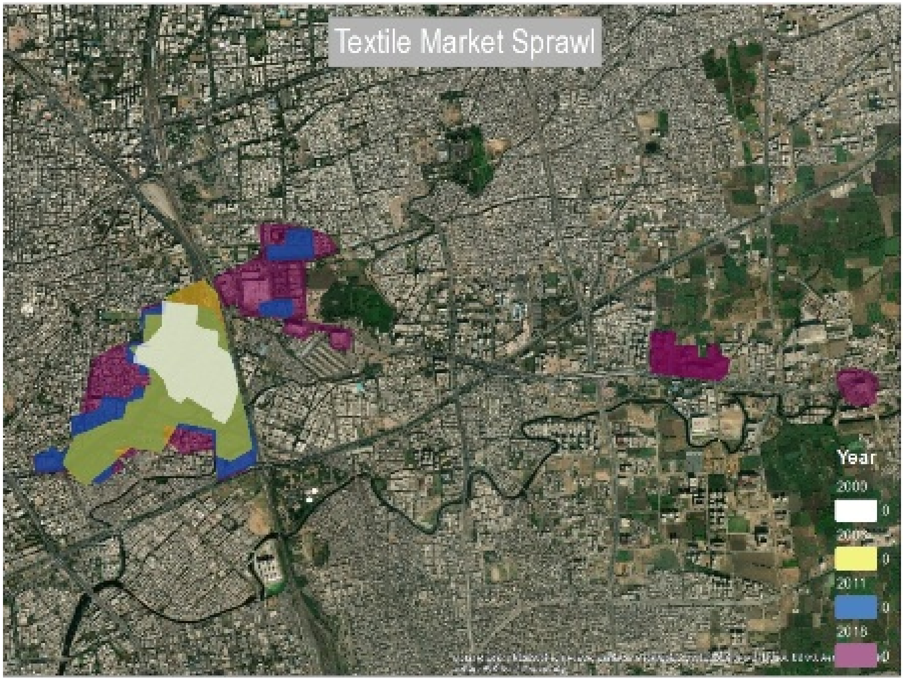

Figure 3 Temporal sprawl of textile market area, Surat

Similarly, the production units also have gradually sprawled out to newer outskirts of the city owing to higher land prices and traffic congestion in the city centre (Figure 4). The sprawl of the textile industry is more towards the eastern side whereby the national dedicated freight corridor (DFC) would be coming up soon.

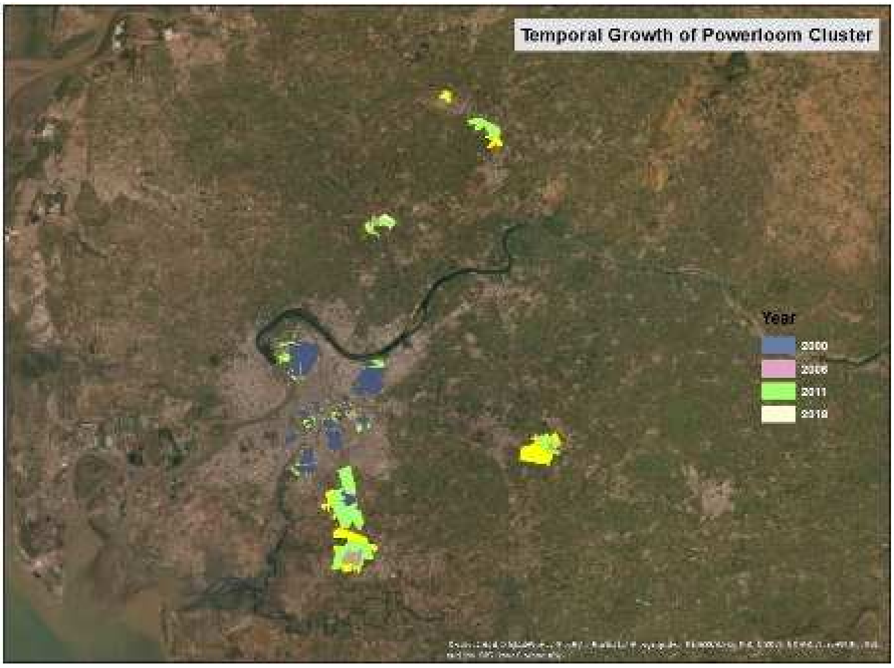

Figure 4 Temporal sprawl of textile powerloom (weaving) units

For both, the maps shown in Figure 3 and Figure 4 colour coding is used to show the expansion of market area and clusters' growth over the years. The textile industry has grown considerably over time. As per recent data, textile production in Surat has grown by 10% in the last 5 years [34]. LCVs having diesel-run engines also have higher emissions than their petrol or natural gas counterpart. The sprawl of textile activities increases pollution in the newly developed area gradually. Environmentalists have carried out studies to measure pollution levels in different parts of the city and the results found and not very encouraging. The city is already facing serious health problems from the high levels of particulate matter (PM) in the atmosphere due to the industrial emissions and noxious fumes of vehicles, particularly in the last two years. Annual PM10 data of the Gujarat Pollution Control Board [35] shows that the particle pollution recorded from 10 locations in the city was much higher than the national average (Table 3).

Table 3 Air quality at different location in Surat

Name of location	PM10 level	PM2.5 level	Activity pattern
Udhana	167	53	Textiles (Weaving)
Bhagal	130	42	Oils and chemicals
Palsana	147	48	Chemicals
Pandesara	171	54	Textiles (Weaving)
Pandesara GIDC	184	55	Textiles (Mills), Chemicals
Chalthan	173	50	Heavy industry, Pipes
Sachin GIDC	188	55	Textiles, Oils
Jolva	184	53	Textiles, Freight Transport
Ring Road (Delhi Gate)	164	54	Public and Private transport

Source: GPCB Data, 2018

Pandesara GIDC which has most of the textile processing houses in the city is having a mean of particulate matter (PM10) at 184 per micrograms per cubic meter of air (µg/m^3) per annum as against the national average of 100µg/m^3. In the ring road (Delhi Gate), where the textile markets are located, at 164µg/m^3 the PM10 levels are exceedingly high. Air Quality Life Index (AQLI) reveals that an increase of 10 micrograms of PM10 (particulate matter that is 10 micrometers or less in diameter) per cubic meter of air (µg/m^3) reduces life expectancy by 0.64 years [36]. World Health Organization has suggested the levels of PM 2.5 at 10 µg/m^3 annual mean and keeping these levels in check may help increase the lifespan in cities [37]. While Surat's annual average PM 2.5 level at 50µg/m^3 is an alarming situation. With the growth of the industry and population growth prospects, it is going to be very tough for city officials to provide room for both the healthy lifestyle and sustainable growth of the city.

4 Estimation of textile industry freight trips

For collecting data related to freight flow patterns in the textile industry, roadside interviews (RSI) of freight vehicles and establishment surveys (ES) of various manufacturing and trading clusters were conducted. Some surveys were also conducted with transport providers to understand the inflows and outflows of freight from the city. The RSI provided the data regarding the type of vehicles, loading capacities, origin-destinations, route, and timings of freight movement in the textile industry. While the ES provided information regarding the daily output and thereby daily trips per unit area of the establishment, number of employees, production capacity, and capacity utilization. The textile industry has cauterization of production units with similar activities based on the availability of labour and other ancillary support. There are clusters of different production phases and trading developed in different areas of the city which is represented on the map of Surat (Figure 5).

It also shows the location of important public transport locations like railway and bus stations. This location is bound to have excessive passenger movement along the road. As per the data obtained from the traffic control cell of the city municipal office, movement of HCV is restricted within the city limits from 7:00 am to 12:00 pm and 05:00 pm to 11:00 pm; also movement of MCV is restricted along the ring road encompassing the central zone of the city. Due to these restrictions majority of the textile goods transportation within the city is carried out using LCVs only. From the roadside interviews of 1137 freight vehicles carried out for 24 hours on a typical working day along with the ring road trip, destinations have been mapped (Figure 6).

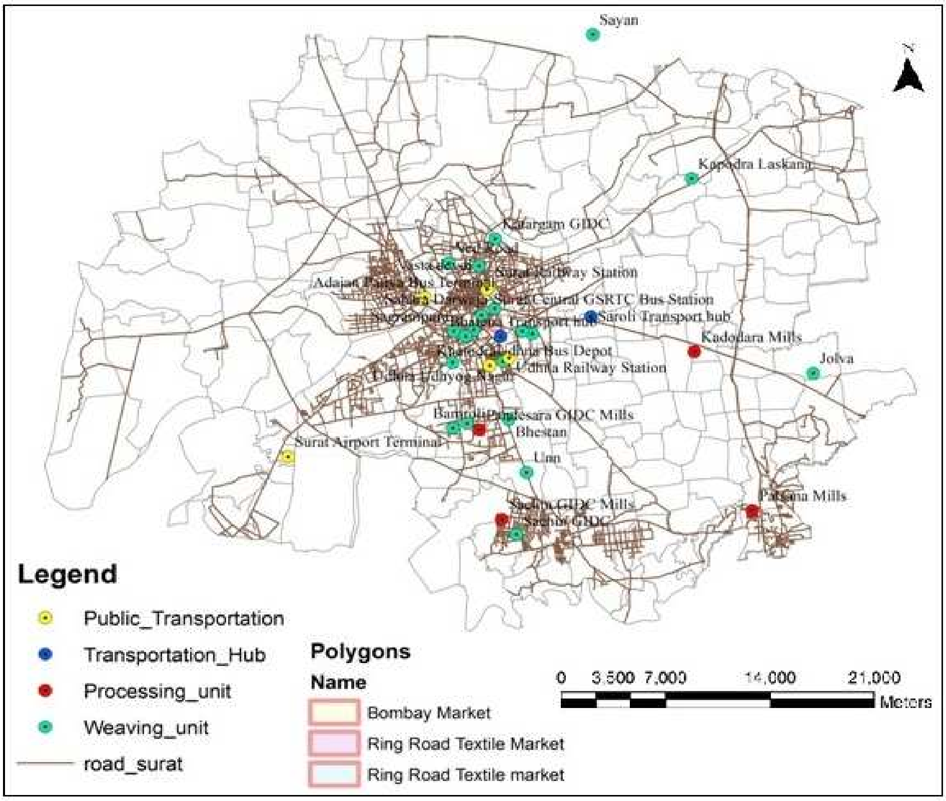

Figure 5 Location of textile industry (production units and market), Surat

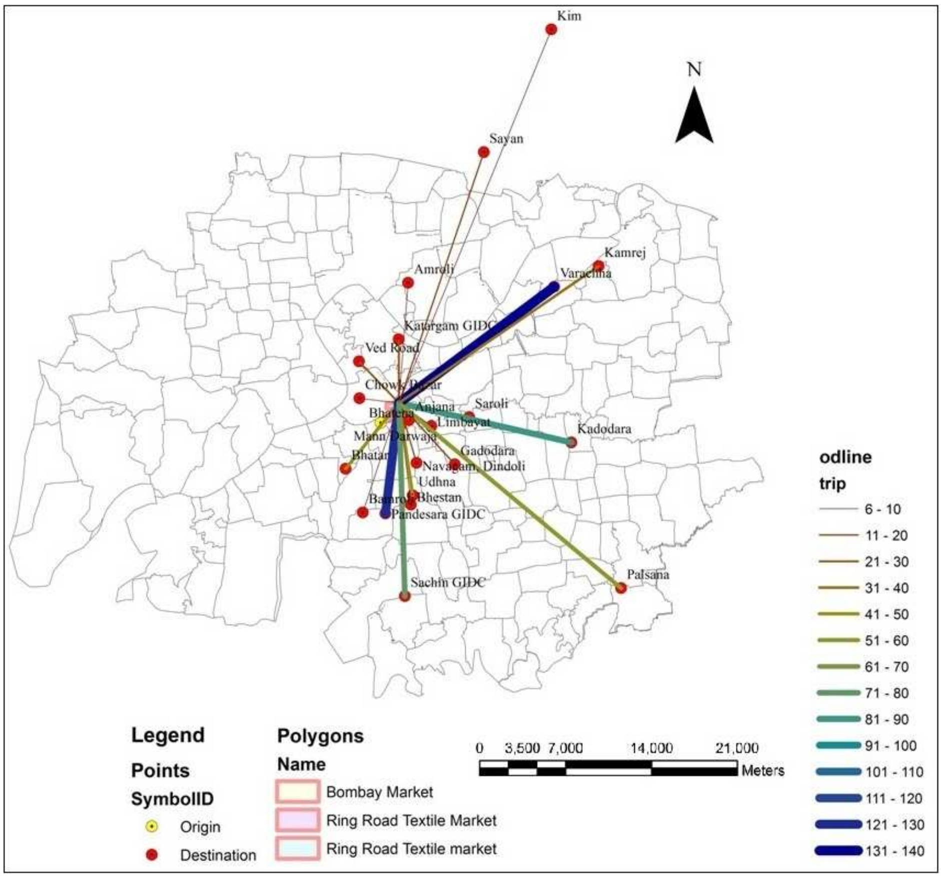

Figure 6 Mapping of LCV trips in textile industry

During the survey, it is also observed that around 20% of the trips originating in the market area and getting completed within the market area itself. It is also observed from the survey that around 35% of the LCVs trips are empty. During the drivers' survey, willingness to electric LCVs (e-LCV) was asked and it was found that approximately 60% of the drivers were willing to shift to e-LCV if they were provided proper facilities (Figure 7).

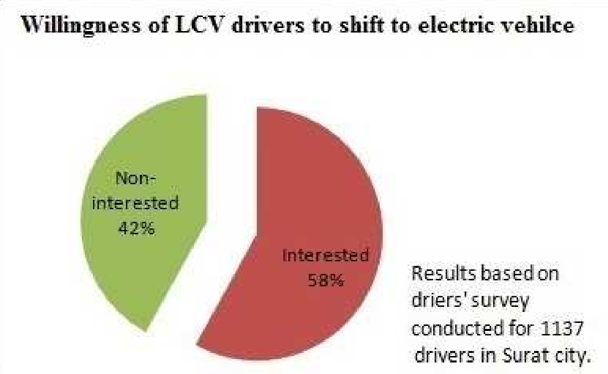

Figure 7 Percentage of LCV drivers willing to shift to electric LCV

Details of the emission standards of the vehicles used were recorded during the survey. It is observed that not all the LCVs used in the city are having the latest emission norms i.e. Bharat Stage IV (BS-IV), on the contrary majority of the LCVs are of the models of previous emission norms. Figure 8 shows the percentage of share of vehicles based on the emission norms.

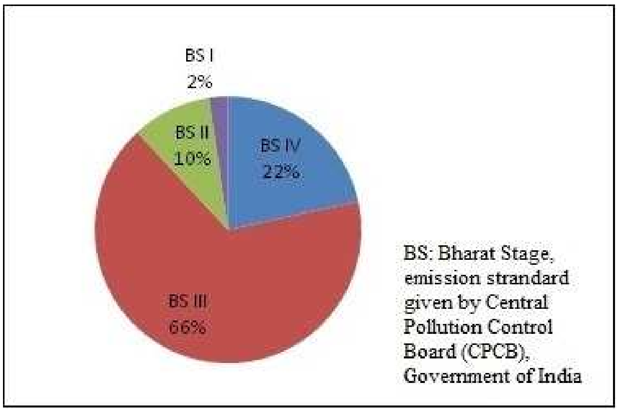

Figure 8 Distribution of LCVs based on emission standards

Also, the trips from the various textile clusters have been estimated using the ES data. The majority of the trips carrying the semi-finished goods within the industry are carried out using LCVs from the manufacturing clusters also. When the map of trips originating from manufacturing clusters was compared with that of the ring road market area, it is observed that similar clusters have been mapped as the destination locations from the RSI of freight vehicles. Figure 6 shows the directional movement of LCVs from various clusters of textile manufacturing. Here clusters from Katargam, Varachha, Udhna, Pandesara are having very high numbers of freight trips, as these clusters are quite old and have a large number of textile manufacturing units (up to 1800 units in a single cluster), while Sachin, Palsana, Kamrej and Jolva which are on the outskirts of the city showing lesser number of freight trips in the map as the number of units in these clusters are less. Also, clusters located in the outskirts do not prefer frequent trips as the distance is more. Establishment survey of production units and trading units enabled designing a trip attraction and production models based on the parameters used in several works of literature on freight trip generation (FTG) (Equation 1).

Multi-linear Regression model for trip generation for goods movement in textile industry is:

$$FTG = 9.686 + [\underset{(0.0264)}{(0.0055 * Q)} + \underset{(0.0031)}{(0.0480 * Npm)} + \underset{(0.0037)}{(0.0074 * A)} + \underset{(0.0013)}{(0.1485 * Ne)} - \underset{(0.0781)}{(0.0167 * D)}] \quad (1)$$

$R^2 = 0.78$

Where,

Q is the quantity of goods produced (kilograms),
N_{pm} is the number of weaving machines at the establishment,
A is the floor area of the establishment (square meters),
N_e is the number of employees at the establishment,
D is the average distance between industrial cluster and distribution centre.

Values given in parenthesis are the p-values for each of the parameters of the multi-linear regression; here the values are statistically significant for each of the parameters. From the multi-linear regression model developed for production units, it is found that though the number of units largely depends on the factors like floor area of the unit, number of machines and labour employed, on an average 15 LCV trips produced per month, also a unit attracts at least 4.5 HCV/MCV trips per month for the supply of raw materials. For the trading units, the number of trips is largely fluctuating based on seasonal variation and overall business trends in the industry. Trading units are not trip generators, but they are trips regulators for different phases of production based on the demand and supply of a particular type of textile goods.

From the details shared 50 major transport service providers, it was understood that mining materials, construction materials, chemicals and oils, consumer goods and are the most important commodities from the tonnage of export and import point of view. Textiles goods contribute about 15% of the total commodities tonnage transported to and from the city. While the intra-city movement of goods within the industry is carried out using LCVs. For the export of goods outside the city HCVs and MCVs are preferred. Textile goods are exported to major cities in the country as well as to major ports for international exports. The major entry points for textile freight in the city are Navsari, Palsana, Kadodara, Pipodara, and Olpad. Traffic coming from/going towards Pipodara and Palsana have very high interaction with Sahara Darwaja where the major textile markets are located. There are 140 market complexes here, which enable business operations of more than 45000 textile traders. During business hours, the entire area of three square kilometres along the stretch between Mann Darwaja to Sahara Darwaja becomes extremely congested due to local goods trips and loading/unloading of the goods simultaneously.

Considering all the stages of the manufacturing process, the textile industry alone contributes around 38–40% of the total urban freight trips (CMP, 2018). Also, most of the chemical and engineering industries within Surat are indirectly associated with the textile manufacturing process. Textile goods movement contributes 32% of the total truck movement and 40% of the total LCV movement in the city (Table 4).

Table 4 Freight trips in Surat and its textile industry

Type of movement in urban area	**Number of HCVs and MCVs trips**	**Number of LCV trips**	**Total trips**
Total goods movement	8041	261,081	269,122
Textile goods movement	3487	105,108	108,595

According to RSI, 35% of the trips are empty, and as per ES of trading and production unit's average trip length of the freight, the trip is 9.8 km. Therefore approximately 370 thousand VKT of LCVs is wasted in the city every day. The economic concern in the terms of financial loss due to wastage of man-hours, fuel, and operational life of vehicles is not the only loss incurred here. There is also a continuous addition of CO_2 and other GHG gases due to this empty movement which is adding an unwanted burden on the city's atmosphere. Table 5 below gives describes the impact of empty vehicle trips on the city's economy in brief.

Table 5 Details of LCV freight trips and its emissions

Description	**Reference**	**Quantity**
Total number of textile freight trips	ES & RSI	108,595
Average freight trip length in textile production	ES & RSI	9.8 km
Total vehicle kilometers travel (VKT)	ES & RSI	1,064,231 kms
Carbon dioxide emission (CO2)	[38]	548.3 tonnes
Sulphur oxides emission (SOx)	[39]	1.51 tonnes
Nitrous oxide emissions (NOx)	[40]	1.36 tonnes
Methane gas emission (CH4)	[41]	95.78 kgs
Approximate empty trips by textile industry	ES & RSI	35%
Empty freight trips (daily)	ES & RSI	38,008
Total empty daily VKT induced by textile industry	ES & RSI	3,72,481 kms

The emissions mentioned above can be reduced if the number of empty trips is avoided by proper planning measures. The LCV trips are short distance trips carrying lesser loads, the possibility of using electric vehicles as a replacement of conventional diesel LCVs would reduce the emission impact largely.

5 Results

The textile industry is generating more than a hundred thousand LCV trips for the internal movement of goods. It is observed that as compared to other industries, textiles are generating far more intra-city trips than that of intercity trips due to the back and forth movement of textile goods during its various phases of production and intervention of textile market at each phase for quality checks. Analysis of the data collected in the RSI and ES survey can be summarized as follows.

The 3 sq. km of the textile market area near Sahara Darwaja is a highly congested becoming bottleneck to the entire road network of that zone. HCV/MCV trips consist only of 8 percent of the total trips, which are also quite organized and efficiently managed. Urban freight trips

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generated from the textile business is one of the major polluting factors in the study area. From the analysis of the surveys carried out it is derived that approximately 190 tonnes of CO2 can be reduced by strategizing land use and freight trips to eliminate empty freight trips that currently comprise 1/3rd of the total LCV trips generated on daily basis. The GHG emissions basically in the form of sulphur oxides and nitrous oxides gases which are harmful to the health of residents of the city as well as contributing towards warming of the city's temperature can be reduced by 500 kg/day and 450 kg/day approximately. As per the survey, approximately 60% of the LCV drivers are willing to shift to cleaner fuel option (i.e. e-LCV), if gradually the use of fossil fuel-based vehicles are replaced by this innovative option, 60% of the total emission can be simply eliminated, which would be a great relief for the alarming levels of PM and GHG at major industrial zones in the city. Reduction of 38,000 empty trips and replacement of 60% of LCV by e-LCVs can together bring a complete change in the existing situation of urban goods movement in the study area.

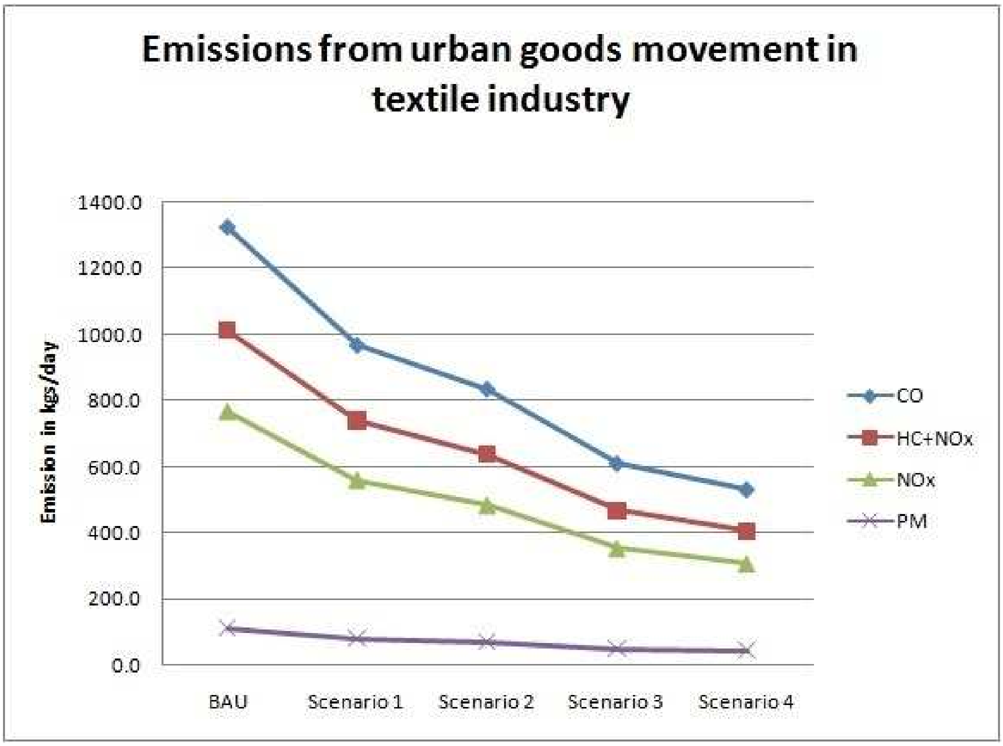

Figure 9 Emissions from urban freight movement in textile industry

Figure 9 shows a graph of different scenarios of the estimated reduction in pollution gases under different solutions sought here. Business as usual (BAU) refers to a current condition with vehicle composition and trip lengths estimated from surveys carried out. Reduction in the emission from LCV trips is considered in four different scenarios. Scenario 1 refers to complete utilization of unused or underutilized payload of LCV trips, scenario 2 refers to the removal of all empty trips (35%) by sharing of freight trips, scenario 3 refers to both removal of the unutilized payload as well as the removal of empty freight trips by sharing of freight trips and the last scenario refers to the replacement of 58% of LCVs with e-LCVs. Scenarios are avoiding empty trips by proper land use planning and management, replacement of conventional LCV with electric LCVs based on the response from the driver's surveys. Here solutions for both the problems i.e. traffic congestion and vehicular emission, arising from the textile industry can have a sustainable solution. Traffic congestion can be reduced by one-third reductions in the overall number of trips or VKT of LCV, while the emissions can be kept in check by replacing the conventional LCVs with e-LCVs.

6 Conclusions

Based on the several recommendations made by GPCB and the prevailing standards of atmospheric emissions recommended by the WHO (Table 3 & 5), it is very certain that cleaner ways of transportation which would have a less negative impact on the environment. From the study, it can be concluded that for reducing vehicular emission and mitigating the traffic situation following strategies can be adopted by city planners and transport planners.

- Textile production houses should be convoked to shift their delivery times to a suitable off-peak hour, which would reduce the overall logistics and parking congestion.

- Local freight transport service providers should be permitted to operate only for a limited area/ zones, to reduce the haphazard movement of LCVs over the entire city.
- Freight depots can be developed at critical locations enabling sharing of freight trips and multi-modal trips, thereby reducing the overall kilometres travel.
- Long term planning for providing electric commercial vehicles and related infrastructure initially in a dense commercial area and later covering the entire city can be carried out by public-private partnership, for example charging ports facility at parking locations

As discussed in the results section, it is possible to reduce the total emissions from urban freight movement in the textile industry by 60%, which is a very progressive move in the direction of cleaner city logistics. The oldest of the industrial clusters which are dense and surrounded by residential properties need to be targeted first for the alleviation of the vehicular emissions. Cleaner production does not necessarily mean to reduce the polluting factors from the production cycles alone, environmental impact due to the freight movement during and after the production cycles of the goods is equally important. Targeting freight intensive industries for cleaner logistics measures gives double benefits to the city, reduction in the overall emissions from these vehicles, and alleviation in the overall congestion which is caused due to these slow-moving freight vehicles. These concepts can also be replicated on other industries like FMCG, dairy, and bakery supplies where the use of LCVs is high A similar concept can be applied to other cities in the country where the textile manufacturing is an important industry in the city. Also with modifications based on industry parameters these models can also be used for other small scale industries in the city and other cities of the country.

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