

Developing IT enabled performance monitoring system for green logistics: An Indian perspective

Structured Abstract

Purpose – Logistics companies are compelled to improve their efficiency and the environmental performance by introducing the green concept in their operations. The main purpose of the paper is to have continuous monitoring and tracking of logistics operations to enhance the green performance.

Design/methodology/approach – This research uses a case study approach. It illustrates a monitoring system to digitize the logistics activities by sending real-time GPS data to the server and capture the surrounding pictures with the help of the Internet of things (IoTs) based camera. Data generated through digitization is mathematically analyzed for ensuring a green logistic system. The alerts due to the halts, help in keeping a check on fuel consumption, carbon emissions, and security of logistics. Performance indicators such as carbon emissions and the value of travel time saving (VTTS) are selected for the study.

Findings -The findings of the study show that the actual travel time and distances are higher than the estimated travel time and distances. It also reveals that actual travel routes with diversions involve a considerably higher amount of carbon emissions during all sample travels. The results indicate a considerable saving in terms of carbon emissions, time and cost savings by effective practices of Green Logistics in Monitoring system (MSGSL). These findings can help the top management of logistics companies in formulating effective strategies for technology applications in logistic operations to ensure green performance.

Research limitations/implications –The study has been carried out under certain set of conditions, which may vary depending upon the organizations. Also certain more environmental dimensions for performance monitoring can be used as a future scope of study. Further studies also need to be carried out to widen the scope of the MSGL model at a global level rather than only at local level.

Originality/value – Any organization which deploys transportation as part of their activity can use this MSGL model and then do the mathematical analysis to reduce the CO₂ emissions, reduce the time and extra cost. The value of this study lies in the fact that Govt is trying different methods and models to reduce pollution. This MSGL should be made compulsory by the govt. as a part of their policies for environment of the country.

Keywords -- Green Logistics, Monitoring system for green logistics (MSGL), Internet of things (IoTs), Global Positioning System (GPS), Carbon emission, Travel time saving (VTTS).

Paper type -- Case Study

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1. Introduction

The Transport and Logistics sector is the backbone of national development and a major contributor to economic growth. The cost of transportation and logistics in India is approximately 14 percent of the Gross Domestic Product (GDP), as compared to 8 to 10 percent of the GDP for developed nations (Chapalkar, 2017; Sharma, 2018). In India, this cost has further increased in the past ten years. It is estimated that India's freight transportation is more than USD 150 Billion. It is expected that the transportation sector will grow at a rate of 9- 10% annually during the years 2018 - 2025 (Deshpande, 2019). The main reasons for this high cost of transportation in India are the higher level of inefficiencies of the Logistics system, such as higher turnaround time, lower average trucking speeds, and high cost of administrative delays (Singh et al., 2020) . These inefficiencies exist due to lack of proper basic infrastructure and conducive environment, lack of tracking and monitoring services, security, and extensive fragmentation of logistics industry (Gupta et al., 2021). As suggested by Rao et al. (2005), the firms can exploit the advantages of efficiency improvement and several other benefits such as market shares and higher profit margins by the introduction of the green concept in the logistics systems.

Green Logistics is a set of supply chain management practices and strategies that reduce the ecological carbon footprints during transportation, packaging, and distribution activities (Stolka et al., 2018). According to Zhang et al. (2010), 'green' logistics is envisioned to guarantee that logistic activities are carried out correctly to minimize adverse impacts on the environment. However, it is very important to monitor the performance of green logistics using various

technologies, which would reduce carbon emissions and enhance profits. The performance monitoring aims to reduce costs and resource consumption, decreased environmental pollution through green practices using IT, stronger brand image, and augmented economic performance by refining environmental and social performance (Dawei et al., 2015). The lack of real-time information during monitoring about logistics activities leads to difficulty in achieving green and cost-effective logistics (Villamizar et al., 2018). This unavailability of real-time information sharing increases the wastage of logistics resources and logistics costs. Real-time information processing and monitoring of logistics activities using IT-enabled technologies can be used for tracing and tracking of goods. Cloud-based Internet of Things (IoT) monitoring devices and systems can be used to cater to the need for real-time information processing in green logistics systems. Liu et al., (2019) discussed a sensing model for a logistics system, which is an IoT-based model with real-time information processing.

Real-time information also enables routing optimization and efficient navigation in green logistics applications. The monitoring of logistics can also help to evaluate accurate routing and delivery time details. Extensive development in technology and information systems has upgraded the performance of the logistics monitoring system. It has been observed that emerging technologies such as big data analytics (Song et al., 2017a), IoTs, cloud computing improve total productivity, precision, flexibility, and employees satisfaction (Song et al., 2017a, Kamble et al., 2018). These technologies also help in reducing carbon emissions. In this context, IT-enabled tools such as GPS-based navigation and IoTs based devices such as real-time cameras can effectively be utilized in logistics to monitor real-time performance. Chhabra and Singh (2016) have observed that Indian logistics companies need to upgrade their operations through digitization. The recent advent of various technologies has provided an opportunity for the logistics industry, especially in India, to

deal with green logistics challenges. Sophisticated technical developments and advanced business models should be employed to develop processes to drive the sustainability of the products through their life cycle (Agostini and Filippini 2019). Since technologies based performance monitoring system for green logistics activities in India is lacking (Chhabra et al., 2017, Singh et al., 2020), the present study has tried to illustrate a case study of an Indian logistics company equipped with an IT-enabled device, to monitor real-time environmental performance. The findings of the study may be used to motivate other logistics companies to use emerging technologies for ensuring green logistic operations.

The organization of the remaining part of the paper is as follows. Section 2 presents a brief literature review about green logistics, implementation of IT-enabled devices/ tools, and performance monitoring. Section 3 describes the development of the MSGL (Monitoring system for green logistics). Subsequently, section 4 gives the implementation of the MSGL system on a case company for illustration. The final section 5 underlines the conclusions, managerial, and future implications of the research.

2. Literature review

Studies on logistics have been spread over a few decades, but a growing economy in this context evolved over recent years. The literature of recent years related to green logistics, importance, need, and implementation of IT-enabled tools and performance monitoring systems have been reviewed thoroughly to justify the research objectives of the study.

Today, the logistics network is becoming more complex and distant due to the worldwide network of supply chains. As the distance to be covered in transportation increases, it tends to increase emissions, which results in climate changes and larger environmental problems. The term “green

logistics” is associated with planning, controlling, and implementing the movement of logistics by integrating modern logistics techniques with an aim to minimize environmental problems (Chang and Qin, 2008). According to Sharma, et al., (2005), green logistics is the capacity of the organization to manufacture and transfer products and services in an environmentally positive way along with economic efficiency and distribute goods by considering environmental and social factors (Song et al., 2016). Green Logistics also helps to move towards sustainability in environmental, economic, and social terms (Lozano, et al., 2012). Thus "green" logistics is envisioned to assure that logistic processes are carried out to minimize the adverse impact on the environment. Green logistics is the development of a strategy to address the issues faced by the logistics industry such as increasing logistics demands, environmental protection, and high-efficiency required in logistics services (Dekker et al., 2012; Rose et al., 2018; Zaman and Shamsuddin, 2017; He et al., 2017). Various activities of green logistics include green transportation, green warehousing and distribution, green packaging, and other value-added services.

This research work primarily focuses on the transportation activity of green logistics. Transportation is the freight movement in the process of logistics activities, which includes loading, selection as well as delivery of the tasks (Zhang et al., 2016). Goods transportation constitutes a tiny proportion of the total transportation time for goods, but it may represent up to 28% of the total transportation costs (Munoz et al., 2018). Another aspect of this research is the green performance evaluation. For each organization, or unit within an organization, the performance measurement system has to be unique reflecting its fundamental purpose and its environment (Isaksson et al., 2019).

Patel et al. (2006) analyzed performance indicators in the logistics sector of India and observed that the sector needed significant development. The implementation of green logistics and performance assessment is moderately significant for existence in an ever-increasingly competitive situation (Kazancoglu et al., 2018). The Performance monitoring of the Green Logistics activities is thus very crucial as it will help in reducing the globalization challenges and ultimately moving towards sustainability (Song et al., 2018). As the proper monitoring of logistics activities is not done so, the lack of real-time information makes it extremely difficult to realize green and cost-effective logistics services (Munoz et al., 2018).

Lack of application of emerging technologies for exchanging data reduces the effectiveness of logistics services (Muñoz et al., 2018). Green logistics management ensures that all the logistics services and activities are managed sustainably with environmental considerations (Lai et al., 2012). One of the major concerns of the logistics resources management system is the inability to obtain real-time information about logistics resources. Therefore the data collected is either manual or barcode-based (Poon et al., 2009). Thus, logistics resources management systems are not capable of implementing the real-time response, monitoring, and handling of activities of logistics. Holweg, et al., (2002) discussed various aspects of the monitoring system design, distribution capability, storage planning, scheduling, and information system along with their integration. Green Logistics management needs an exchange of information, coordination, and collaboration of teams to increase productivity and efficiency (Zhu et al., 2018). Martinez et al., (2009) discussed the lack of knowledge and control of the status of the shipment vehicles in real-time conditions. In the present business situation, the current and future generation of logistics activities in

manufacturing organizations is significantly influenced by the rapid advancement of IT (Luthra et al., 2019).

Millions of transport shipments are managed and monitored worldwide. VanDorp (2002) gave a structure of tracking and tracing practices and further added the possibility of better control over logistics for the company's profit and environment. Jedermann et al. (2006), discussed various auto-identification technologies and a comparison between them. Bechini et al. (2007) defined traceability as the ability to trace the location, application, and history of an entity through recorded identifications. He et al. (2009) investigates all the auto-identification technologies thoroughly and collects tracking data such as location, temperature, and speed. Ruiz (2008) focused on the efficient way of tracking and tracing the green logistics through Barcodes, QR codes, RFID, WSN, and GPS. Logistics companies should be more flexible and efficient in harsh delivery conditions. Holmstrom et al. (2009), in their research, presented the potential ease of object-centric tracing, which depends on recent technologies to monitor the flow of material on item level instead of material level. Li et al. (2001) introduced a roadmap to track businesses and technologically rich products. It attempts to explore all recent advancements in logistics management globally, which allows the monitoring of transport vehicles. Along with the tracking system, monitoring involves efficient alarm and alert systems. Indelsia (2000) built a system to enhance the logistics security in which coded signals were being sent to the receiver connected to the logic controller for activation of fuel and speed control mechanism.

Various anti-theft alarm systems were introduced for motor vehicles. These systems were integrated into logistics monitoring for better security and safety. Eric Anthony, (2009) has observed the need for various alarm systems to reduce automobile theft, accidents, and vandalism. The majority of such systems are based on vibration or touch sensors that will sense the presence

of a person attempting to open the vehicle. There exists a need for an alarm system that provides notifications to the monitoring systems in case of unnecessary circumstances. It should be cost-effective, along with video surveillance technology. Matsushita (2003) introduced surveillance systems in logistics to transmit images through the internet, but it was based on batteries and turned out to be non-economical. Ghosh et al. (2008) introduced an active alarm system to predict collision between vehicles using the Global Positioning System. These warning systems help decrease losses due to accidents and save the wastage of goods. Although enormous progress has been made in the area of green logistics and its activities, still important activity such as transportation requires more performance-focused studies. Significant challenges exist in terms of the monitoring of green performance during transportation activities, especially in developing countries like India. From the above discussion, it is observed that green logistics monitoring and management in India need attention. This sector has started garnering the attention of researchers and practitioners, but there are still some limitations present. Some of these challenges, and research gaps in context to the logistics sector can be listed as follows:

- Lack of complete real-time information monitoring of transportation in green logistics.
- Very few security systems have been developed for monitoring the transportation of products and raw materials in a greener context (Liu et al., 2018).
- The rapid increase of green logistics demands and performance monitoring system
- Most of the existing technologies are barcodes and QR codes. Application of emerging technologies such as BDA, GPS, IOTs in logistics is still lacking (Wang et al., 2018).
- In India, only a few alarm generation and anti-theft systems are developed for trucks and shipments during transportation.

- Existing technologies are generic and therefore are not cost-effective. These are integrated into the vehicle only not with the complete logistic system

3. Development of Monitoring System for Green Logistics (MSGSL)

One of the objectives of this research is to develop a green logistics monitoring system using IT-enabled technologies to track and manage the overall logistics network involved in the transportation activities of raw materials and finished goods. The development of the proposed monitoring system should be initiated by studying the existing monitoring systems being utilized in the context of the Indian scenario. In the transportation sector, popular technologies such as radio Frequency-based data capture. Wi-fi network-based location tracking (Halwa et al., 2019), and traditional satellite tracking (Gao & Mai, 2018) are being used in India and other Asian countries. Based on our research objectives and on the basis of a review of popular existing tracking and monitoring technologies, a conceptual design of the system is proposed. The System Architecture of the MSGSL and flow diagram are described in the remaining part of this section.

At the outset, we shall discuss the system architecture of the MSGSL conceptual model, later the process flow and algorithm design will be presented. The MSGSL model is based on few assumptions. It is assumed that all the components of the model are integrated fully for the flow of information. Another assumption is that the model operates without any allowances and tolerances during the flow. MSGSL model is primarily based on two technologies viz. global positioning system module and an IoTs based camera module. Both of these devices have been integrated using necessary components and built on the industry-leading small form factor platform to provide portability factor to this MSGSL model. Vehicles in the proposed transportation system are supposed to be equipped with a GPS module (Make- Graylogix SKG13), an IoT based

tracking CMOS camera (Make – 8MP Raspberry Pi compatible) module with google lens® or similar AI-based tracking technology. Apart from these essential sensors and devices, some auxiliary devices such as mini form factor motherboard (Make- Raspberry Pi-3), automotive compatible portable power supply modules to power different devices/ components, and few sets of transceivers to communicate with cloud-based database servers. The proposed architecture shown in figure-1 is a 3-layer model with a bottom layer dedicated to the portable subsystems onboard with moving vehicles in a transportation system. The middle layer is making a sandwich-type cloud link with monitoring servers located in supervisory control rooms. The top layer is designed to provide a communication link to the moving vehicle via a cloud layer and to implement control and supervisory set of rules in a green logistics system based on the monitory outputs from MSGL. The moving vehicle sends the real-time location data and other data sets in the form of latitude and longitude and an array of pictures of surroundings. Alarm based alert creation system is also included in the bottom layer to keep a check on the routes and halts of the vehicle. In case of any suspicious halt, an alert is generated and sent to the middle layer side by initiating a camera onboard. This camera will automatically start sending images of the surroundings of the halt location of the shipment vehicle.

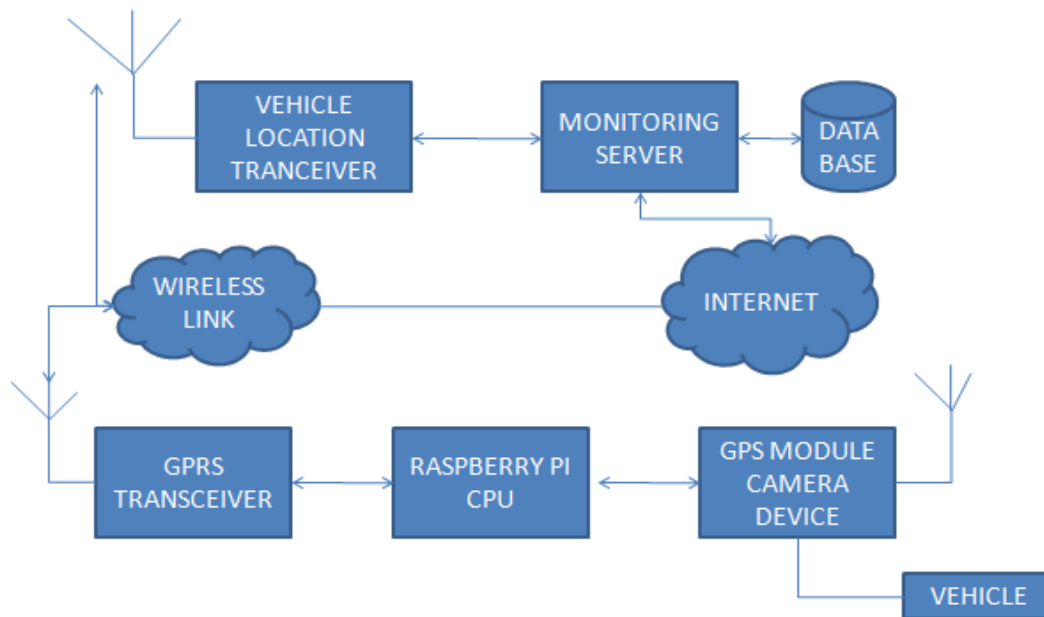


Figure 1: System Architecture of Green Logistics Monitoring System (Source: Self)

MSGSL architecture, as explained above, will now be explained with the help of the flow process diagram (Figure 2). The proposed system sequentially integrates all the components as discussed in the architecture and creates a flow of information. Sequential integration is the stepwise integration of all the modules required for the acquisition, computation, and communication of the data received and sent during any monitoring process. In the very first step, as the vehicle starts, the power supply is provided to the system comprising Raspberry Pi, GPS module, and Raspberry Pi camera initialize. Furthermore, the moving receiver of the GPS module uses navigation data and measurement data from the base stations through an RF communication link and data corrections for the applicable satellites. In the next step, the GPS module sends a real-time GPS location on a server as it moves towards the destination. The data received by the GPS module is computed by Raspberry Pi and converted into the standard NMEA format. Further, this data is sent via the wireless link of GPRS transceiver through the internet. The monitoring server will obtain data from the signals sent by the GPRS transceiver and obtain real-time location details. Then the

server will keep a check on the location and route, and whenever there is a pre-defined halt, Pi will check for all the allowed locations for the stoppage. In the case of an undefined stoppage, the timer will initialize, and the Pi camera will be activated. In the final step, the camera starts capturing images every minute of the surrounding where the truck halts. This will provide pieces of evidence of any theft, accident, or vandalism. The images and location details are organized in the database for future evaluations.

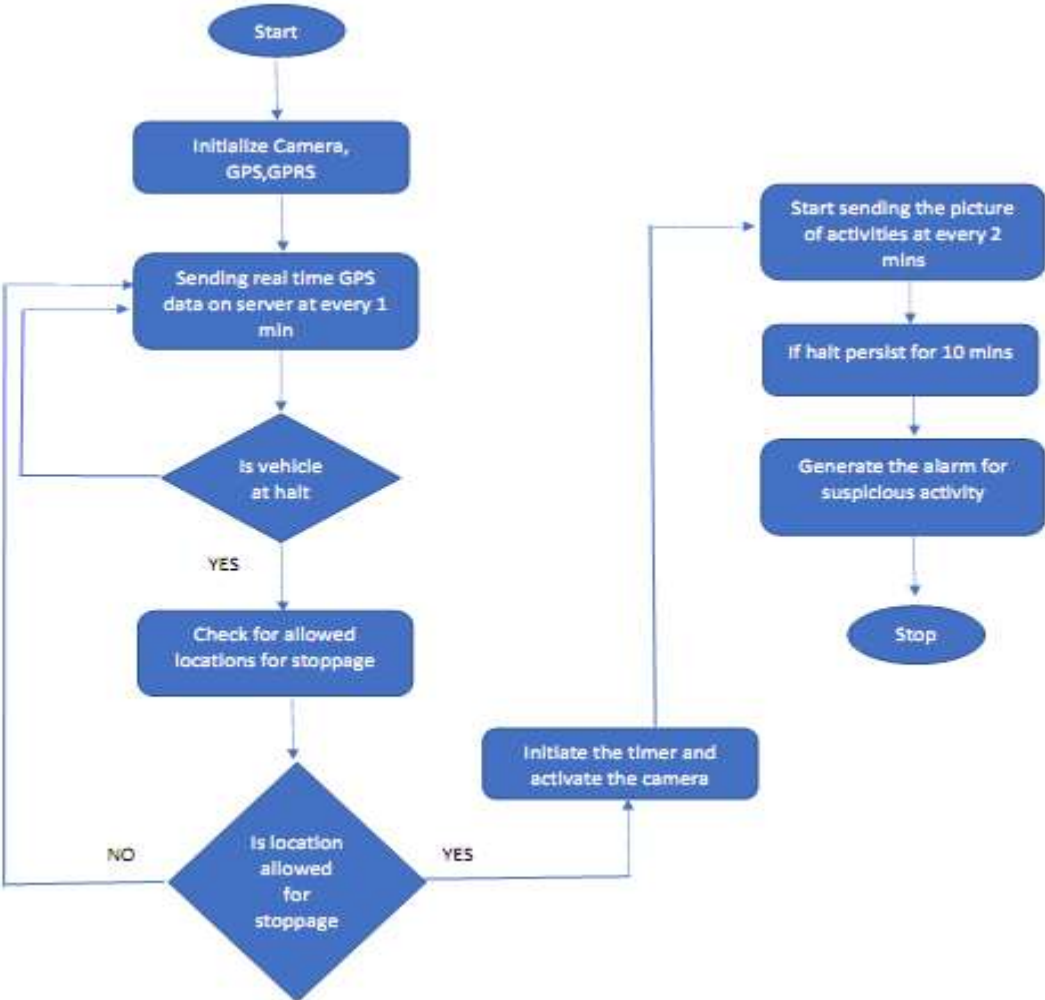


Figure 2: Flowchart of the GL Monitoring System (Source: Self)

4. Case Illustration of Monitoring System for Green Logistics

The proposed Monitoring System (MSGSL) is expected to enhance the sustainable and economic performance of an Indian logistics sector. A case of an Indian logistics company is considered to illustrate the functioning of this monitoring system. XYZ Logistics Pvt. Ltd is a multimodal logistics company established in the year 1997 and based in National Capital Regional Delhi (India), which provides distinct logistic solutions across the country. The company has 53 branches present across the country and has over 100 destinations for delivery, with a daily freight capacity of over 230 tons. The XYZ company is one of the fastest-growing players and offers the most efficient delivery schedule through Air, Train, and surface. The case company employs over 250 professionals to create sustainable and reliable logistics. Following are the key focus areas:

- Reductions in Carbon emissions
- Sustainable warehousing
- Vehicle efficiency
- Reporting of carbon footprints

The company is thriving to achieve these focus areas by adopting all possible measures available in today's technological environment. The company follows few environment-related policies. It focuses on the integration of environmental attributes and cleaner production in their business processes and practices. Also, it has a green policy to protect the environment through the prevention of pollution and reducing environmental risks. As this company is in a growing phase, therefore it is important to select a cost-effective way to achieve small eco-sustainable goals for moving towards the green logistics domain. The Company has aggressively focused on publishing environmental reports. It also takes an extra effort to provide special seminars and training programs to the staff for green practices. The Company has set a target of Carbon Neutrality by year 2030. Our proposed monitoring system for green logistics (MSGSL), as described in the

previous section, has helped the company in achieving its focus areas (reduction in carbon emissions). The company after the implementation of MSGL has reduced the energy spent in vehicles during transportation alongwith the reduction in carbon emissions. For this study, nearby transportation routes have been selected to validate the performance parameters. These routes include places such as Gurgaon, Sohna, Manesar, and Faridabad in NCR Delhi, India. Real-time locations and other data on routes of these places have been tracked and stored on the cloud using onboard Raspberry Pi-3 equipped with GPS/GIS module installed inside the sample trucks. The performance indicators are specific measures used to evaluate the progress towards the goals. Various performance indicators for MSGL are as follows:

- The Value of Travel Time (VTT): It is defined as the total cost of the time spent on transportation. It includes costs to the company in respect of vehicles, employees, and customers (unpaid) spent on total travel. Therefore, the value of Travel Time Savings (VTTS) is defined as the benefits of reduced travel time costs (<http://bca.transportationeconomics.org/>).
- Vehicle Costs- It is defined as the overall changes in the costs of owning and operating vehicles (including all types of vehicles such as trucks as well as cars) resulting from a transportation improvement that is counted as benefits or disbenefits (<http://bca.transportationeconomics.org/>).
- Safety indicator- It represents the change in traffic accident rates (<http://bca.transportationeconomics.org/>).
- Carbon Emissions- It can be measured in terms of the costs of increased air pollution emissions and the benefits of emission reductions. It can be quantified by estimating the changes in vehicle distances, vehicle-hours, and vehicle-trips for different vehicle types (<http://bca.transportationeconomics.org/>).

In this section, the proposed MSGL model will be illustrated for the case company (XYZ Logistics Pvt. Ltd.) by initially considering only two performance indicators out of the above four indicators viz. VTTS and Carbon Emissions. During the observation, it was recorded that various trucks originated from the base warehouse location, viz Gurugram, India. There were three sample locations considered for this study that are Manesar, Sohna, and Faridabad. Real-time data were collected for ten days with onboard MSGL implementation on the trucks moving on these sample routes. During the execution of the MSGL model, the GPS coordinates were recorded as an input to initialize the automatic camera capture and send it to the cloud server in the case of the halt. As per the architecture, the halt generates an alert message string that is sent to the control room via cloud storage. Data string has been generated using Python array (Python shell snapshot given in the Appendix-1) The system records time estimations (actual and estimated) during the above activities. This data has been summarized in Table 1.

Table 1: Truck travel time data (estimated and actual)

Date	Starting Location	End Location	Vehicle ID	No of Defined stoppage	Estimated Travel Time (Min)	No. of Undefined stoppage	Actual Travel Time (Min)
1/06/2019	28.4595 77.0266	28.3543 76.9398	HR7CP7829	3	55	4	80
2/06/2019	28.4595 77.0266	28.3543 76.9398	DL3CK7638	3	57	3	75
3/06/2019	28.4595 77.0266	28.3543 77.0698	HR8FP7369	5	70	3	100
4/06/2019	28.4595 77.0266	28.4089 77.3178	UP7CP3559	3	90	4	115
5/06/2019	28.4595 77.0266	28.4089 77.3178	HR8FP7369	5	108	2	115
6/06/2019	28.4595 77.0266	28.3543 77.0698	HR8FP7369	3	53	3	70
7/06/2019	28.4595 77.0266	28.4089 77.3178	UP7CP3559	5	95	3	117
8/06/2019	28.4595 77.0266	28.3543 77.0698	UP7CP3559	3	59	4	90

9/06/2019	28.4595 77.0266	28.4089 77.3178	DL3CK7638	5	90	2	103
10/06/2019	28.4595 77.0266	28.3543 77.0698	DL3CK7638	4	60	5	88

Table 1 data indicate that during all sample travels of the trucks, the actual travel time is more than the estimated travel time due to a few undefined halts/stoppages. The causes of undefined stoppages/ halts are unnecessary driver issues, traffic conditions, vehicle breakdowns, and construction work. These halts were recorded accurately with the help of IT-enabled technologies incorporated within the MSGL model. To get a clearer picture of the effect of these halts, a graphical representation is drawn and shown in figure-3. It depicts the variability of these travel times.

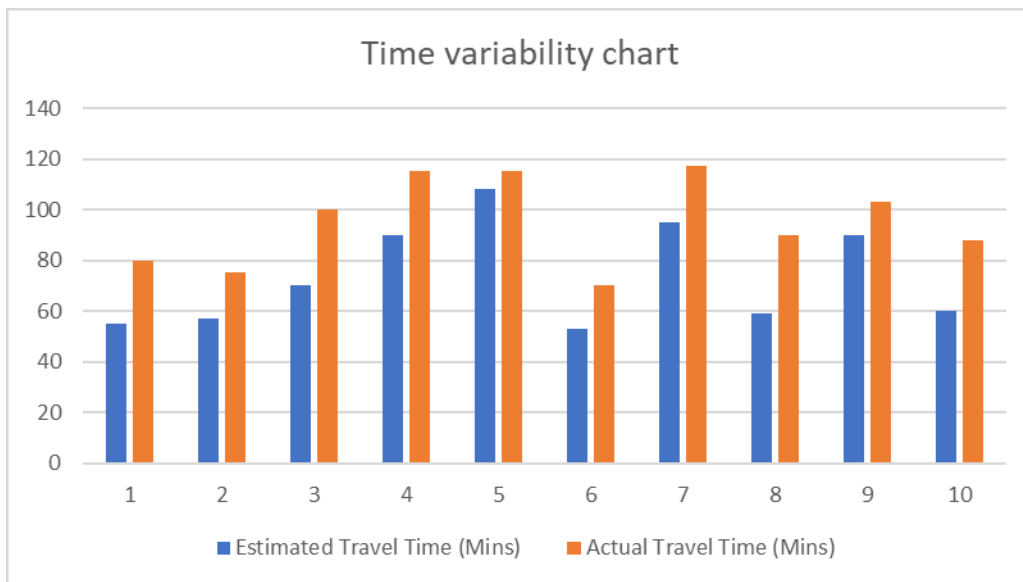


Figure 3: Time variability chart (Estimated vs. Actual Travel Times – Effect of halts)

One of the significant impacts of higher travel time than the estimated is on the VTT (value of travel time). The VTT has already been defined above as one of the performance indicators for proposed monitoring system. The higher value of VTT affects VTTS that is the value of travel

time savings. The workforce cost in this company for truck travel is USD 0.74 per hour, and this cost has an impact on VTTS that has been shown in Table 2.

Table 2: Additional costs (VTTS) due to MSGL recorded halts

Date	Actual Travel Time (Min)	Estimated Travel Time (Min)	Travel Time Difference (Min)	Additional Costs (VTTS)
1/06/2019	80	55	35	30.71
2/06/2019	75	57	18	15.79
3/06/2019	100	70	30	26.33
4/06/2019	115	90	25	21.94
5/06/2019	115	108	7	6.14
6/06/2019	70	53	17	14.92
7/06/2019	117	95	22	19.06
8/06/2019	90	59	31	27.20
9/06/2019	103	90	13	11.40
10/06/2019	88	60	28	24.57

Another focus area of MSGL implementation, in this case, is environmental emission reduction. Carbon emissions (kgCO₂) in the logistics and transport sector are dependent on the level of travel activity, emission factor in kgCO₂/km, and the category of freight vehicles as per the standard data in table 3. As per this study, the type of trucks carrying the load is under the category of HDV(Heavy-duty vehicles) which has an emission factor of 0.7375kg CO₂/km. Therefore for all the calculations of emission factor HDV value will be used from table 3.

Table 3: Emission factors for freight vehicles (India GHG Program, 2015)

Sl. No.	Category	kg CO₂/km
1	LDV (Less Than 3.5Tonnes)	0.3070
2	MDV (Less Than 12Tonnes)	0.5928

3	HDV (More Than 12Tonnes)	0.7375
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Another critical problem with freight trucks is the diversion from GPS defined routes. The route diversion may be caused due to reasons such as driver's route prejudices, traffic diversions, little knowledge of routes, and other related factors. The MSGL system design is also equipped to address these issues by reporting such diversions automatically to the control centers. In return, control centers can issue live warnings on such occasions, and, can impose suitable penalties to such drivers. These diversions do have a severe impact on carbon emissions. Table 4 presents calculations for carbon emission increased due to diversions observed during the real-life data of ten days from the sample case.

Table 4: Calculation table for the increase in CO2 due to route diversions

Travel Date	Estimated Total Distance Travelled (Kms)	Emission Factor for Feight Trucks (kgCO2/km)	Co2 Emissions during Estimated Travel kgCO2	Actual Total Distance Travelled (Kms)	Emission Factor for Feight Trucks (kgCO2/kg)	Co2 Emissions during Actual Travel kgCO2	Increase in CO2 Emissions due to diversions kgCO2
1/06/2019	36	0.7375	26.55	40	0.7375	29.5	2.95
2/06/2019	36	0.7375	26.55	42	0.7375	30.975	4.425
3/06/2019	28	0.7375	20.65	32	0.7375	23.6	2.95
4/06/2019	90	0.7375	66.375	94	0.7375	69.325	2.95
5/06/2019	90	0.7375	66.375	95	0.7375	70.0625	3.6875
6/06/2019	28	0.7375	20.65	33	0.7375	24.3375	3.6875
7/06/2019	90	0.7375	66.375	97	0.7375	71.5375	5.1625
8/06/2019	28	0.7375	20.65	34	0.7375	25.075	4.425
9/06/2019	90	0.7375	66.375	95	0.7375	70.0625	3.6875
10/06/2019	28	0.7375	20.65	35	0.7375	25.8125	5.1625

It is observed that during all time, due to diversion, CO2 emissions have got increased. Therefore proposed monitoring system will help to analyze the impact of route diversion on the

environmental performance of the logistic company. These data generated will also help in proper planning for resource allocation and network optimization.

5. Conclusion, Limitations, and Managerial implications

In an era of the circular economy, monitoring of logistics vehicles in terms of sustainability measures has become a strategic area across the world. It is gaining new attention in emerging economies like India. The logistics sector is facing multiple challenges for improvement in CO2 emissions, minimization of cost, and lead time reduction to achieve sustainability in operations. To overcome different challenges, many logistics companies are using emerging technologies such as IoTs, BDA, Artificial intelligence, etc. The use of such technologies in the Indian logistics sector for monitoring environmental performance is at a nascent stage. Therefore, this study tried to validate the use of emerging IT-based technologies for developing a monitoring system for green logistics (MSGSL).

This study is broadly divided into three segments. Firstly, an elaborative literature review is carried out on green logistics, implementation of IT-enabled devices/ tools, and performance monitoring. This gives an overview that the focus on green logistics and the use of IT based tools in the monitoring of such logistics is very rarely used and implemented in the Indian industries and organizations. The second segment discusses the proposed MSGSL model architecture by highlighting components, hardware details, and connections. The model has been framed following few assumptions. The flow of the information in the model is integrated through all the components sequentially. The final segment provides the sample illustration of the proposed MSGSL model in a case company based in Delhi NCR (India). The case company has trucks that move on particular routes and are studied for ten days. The data is obtained for the carbon

emissions by the HDVs during those ten days without using IT tools. Carbon emissions and the value of travel time saving (VTTS) are the two crucial performance indicators, that have been used in this work for illustration of the proposed MSGL framework. In the typical Indian scenario, the case results show that the actual travel time and distances are higher than the estimated travel time and distances. There can be various reasons for the increase in time but with the implementation of IT tools the reasons can be known. The findings depict the total increase of 226 minutes in time and USD 2.77 in cost due to route diversion for the 10 days of the case study. In the longer run, these savings would be huge. If the same situation continues, the savings would be USD 101.10 in a year. An implementation of the MSGL system could have saved this significant time and cost as management would have planned accordingly. This time and cost-saving is a significant finding. Findings of this study could further be validated through more case studies in the future.

The findings also revealed that actual travel routes with diversions involve a considerably higher amount of carbon emissions during all ten sample travels. Additional CO₂ emissions up to 5.1625 kg CO₂ were observed in these travel routes for a total of 10 days to and fro trip. This is the significant amount of saving of CO₂ emissions by incorporating a monitoring system, as proposed in this study. The findings of the study are in line with the theoretical implications as it is being stated that the implementation of the MSGL model helps in reducing carbon emissions. Monitoring improves the performance in terms of environment measures. The model discussed reduces the distance traveled and carbon emissions from the vehicles under the study. The findings of the study will help the top management of logistics companies in formulating effective strategies for sustainable operations. The results will motivate the management to adopt the MSGL system as it shows the savings not only in terms of environmental measures but also in terms of economic dimensions. The study has been carried out for a particular case, and thus the results may vary for

different cases under a different set of conditions. More environmental dimensions for performance monitoring can be used as the future scope of the study. Further studies also need to be carried out to widen the scope of the MSGL model at a global level rather than only at the local level.

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