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The importance of public support in the implementation of green transportation in the smart cities

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Abstract

Smart cities are increasingly evolving, initializing new strategies, and programs that have a significant influence on policy making and scheduling while coexisting with urban facilities. To recognize urban planning offers to a smarter city context, it is now necessary to understand the contribution of the smart city in overall urban planning and vice versa. Currently, transportation has been seen as a connection to all aspects of life across the world. This article presents the results of a survey testing into whether the public supports the concept of green transportation in the smart cities. The green urban mobility model has been proposed to investigate urban traffic information to characterize important features of smart mobility in the smart cities. The development of intelligent transportation systems using the proposed model that makes traffic easier in the city to transport safe and more comfortable. The experimental results suggest the required factors of green transportation and realistic behavior of smart mobility.

KEYWORDS

green transportation, public support, smart city, smart mobility

1 | IMPORTANCE OF TRANSPORTATION PERFORMANCE

Road traffic is one of the main impacts in many cities around the world for environmental pollution and hazards.[1] To improve transport performance and achieve the aim of smart green cities, energy-efficient protocols, and systems have attracted the research community.[2] Fuel consumption and air pollution can be minimized by drivers and passengers sharing their knowledge and road experience. Social vehicle networks are built on top of ad hoc vehicle networks, allowing riders to communicate with neighboring nodes (passengers, vehicles, and drivers), and exchange their data with them.[3] Current carbon recorder, a mobile social application that encourages drivers not only to enhance behavior, but also to allow data collection platform and social awareness that can be utilized by the research community and green transportation traffic representatives.[4]

Transport, an integral, basic infrastructure for economic growth, is one of the most important elements of the logistics.[5] Transport scheduling quality has a significant impact on the performance of supply chain operations and logistics as well as on market competitiveness.[6] Transport has significant environmental effects and it is crucial to minimize transport carbon emissions. Modern cities, however, still suffer from a vicious circle of traffic congestion formed by unsuitable measures to manage traffic.[7] A realistic framework based on the concept of sustainable development for the smart city should be built with a certain amount of transport demand and difficulty in road reconstruction and expansion.[8] The role it plays in solving urban transportation problems should be long-lasting and more efficient than the blind expansion of transport supply to increase its proportion of high-efficiency, low-energy, low emission, and high-speed modes. Human society and the natural environment will evolve harmoniously as well (Figure 1).[9,10]

Smart sustainable urban mobility includes three parameters,

Electrify fuels: Support the use of electric vehicles and transition from localized research to electric transportation systems;

Optimize efficiency: Support the strategy and implementation through participation and study of higher standards for fuel and vehicle efficiency and lower energy usage and transportation emissions.

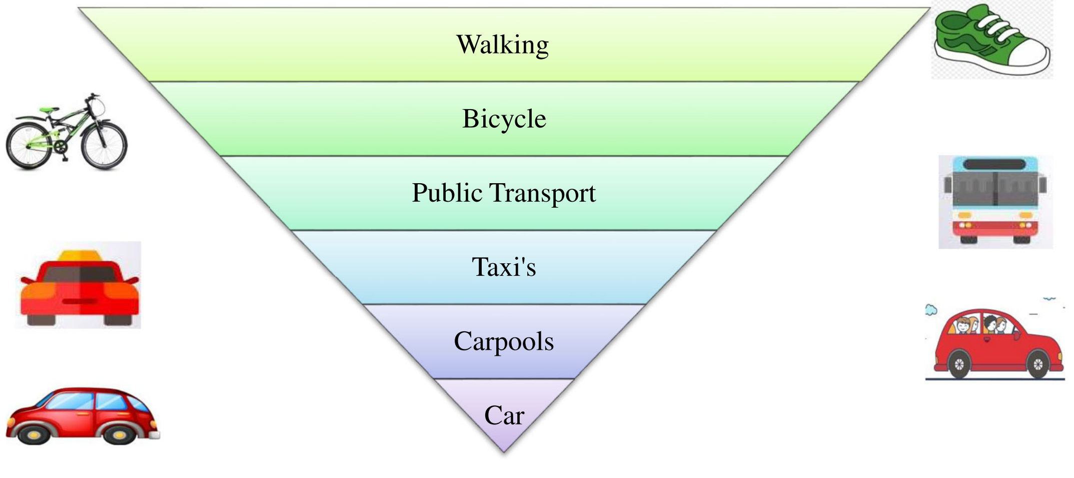

FIGURE 1 Green transportation [Color figure can be viewed at wileyonlinelibrary.com]

Integration systems: Support the development and management of integrated transportation systems by directly influencing urban transport system design and implementation and the dissemination of high-quality research.[11-15]

Green transport has several reasons, such as air pollution, the production of greenhouse gases, increasing degradation and mining of natural resources, increased oil resource imports, and a rise in fuel prices.[16] Reduced traffic congestion is one of ITS's main advantages and thus very important in urban environments, where the urban profitability of congestion is greatly decreasing. Considering this demand, the forays in ITS research and development in India are comparatively small because of complex traffic patterns and diverse transport modes across different cities.[17-20]

In this article, we propose a green urban mobility model (GUMM) for green transportation in the smart cities. GUMM mathematical model has been proposed for the performance analysis with a cost-effective scenario. The main contribution of the research article is followed by,

(i) To provide a quantitative context to evaluate road design and maintenance, sustainability, and green transport initiatives.

(ii) The transportation scheduling problem has been illustrated using GUMM mathematical model and to minimize the fuel consumption and transportation emission by driver travel behavior.

(iii) The proposed GUMM approach will be validated by numeric simulation and discussions on experimental results.

The rest of the article decorated as follows Sections 1 and 2 discussed the related works of green transportation. In Section 3, we discussed the problem description and mathematical model. In Section 4 experimentation and numerical simulation has been discussed. Finally, Section 5 concludes the research article.

2 | RELATED WORKS

León-Coca et al[21] proposed the wireless access in a vehicular environment (WAVE) technology for intelligent transportation systems in the smart cities. WAVE is a wireless technology framework for working in difficult, hash-like environments that provides fast communication between mobility-like vehicles, enclosed safety messaging thresholds with high QoS delays, maximum electricity consumption, and privacy and roaming user anonymity, and many other environmental challenges. WAVE was also designed for safety applications like vehicle stationary warning, vehicle emergency warning, hazardous location notification, roadwork warning, collision prevention, and so on.

Khorani et al[22] introduced the imperialist competitive algorithm (ICA) for urban traffic and traffic optimization. This model allows a manual change in a coefficient called the escape route to minimize the number of cars on the underlying roads. The results have shown that the algorithm proposed can control traffic efficiently. The use of escape route, which provides the model to allow for the concentration of vehicles through the region, is a contribution to this article in the existing research. In this approach, traffic in a modern city can be optimized and regulated. It can also prevent potential traffic interruptions and predict them.

Xia et al[23] suggested the simulation of urban mobility (SUMO) for green transportation. To estimate the microscopic mobility of vehicles, we choose an open-source discrete-time traffic simulator called SUMO. SUMO has the potential to more precisely model the human behavior. SUMO facilitates the importation of route maps, including open street maps from multiple sources. In addition, SUMO provides multimodal modeling of traffic flexibility with portable libraries that is scalable, time-planned. SUMO provides dynamic solutions in different areas of research, such as navigation, traffic management, communications with vehicles, and routing. For performance analysis of socially competent VSN propagation and routing protocols, SUMO can be used to produce macroscopic and microscopic models for mobility, and the resulting trace files can be imported into network simulators, including NS2 and NS38.

Hu et al[24] proposed the social drive a crowdsourcing based vehicular social networking (CVSN) for green transportation. The social drive incorporates the standard vehicle OBD module, combines the benefit of the popular social networks, cloud computing and introduces a new rating system for drivers fuel economy. Social drive allows a user-friendly smartphone application aimed at drivers. It helps drivers to be aware of their driving behavior in fuel-saving on their journeys at a smooth and economical cost. Currently, several mobile crowd source-based applications for vehicle application scenarios, such as UbiGreen, Cyberphysical Bike, HyDi, and Green GPS have successfully been implemented for green transport.

Guo et al[25] proposed a novel evolution-strategy-based memetic Pareto optimization (ESMPO) for green transportation planning with transport mode selection and pick up. This article was implemented a new multiobjective method of memetic optimization, called ESMPO, to manage the studied transport planning issues, to handle the multiobjective function and cut calculator time. Not only does the new problem of transport planning, discussed with essential practical features, though the latest ESMPO solution has also been introduced in the new article.

To overcome these issues, the GUMM has been proposed for green transportation in the smart cities. The mathematical model describes and solves the problems in the transportation industry. Considering the actual conditions of traffic, climate, and road limitations, it proposes the concept of general cost and liberates the impacts on the costs of travel of each mode, which could enrich the theory of traffic structure researches by quantifying the effect of travel factors.

3 | THE MATHEMATICAL MODEL OF GUMM

This section presents the models and variables used to describe various sustainable transportation systems. Consider a practical transport scheduling problem pervasive in a manufacturing company. After the production of products has been completed, the company transfers the number of orders requested by a distribution center. Eventually, other firms will send orders to consumers. Based on customer requirements, the quantity of transport orders is determined. A variety of delivery orders are available based on customer requirements $j, j \in J = \{1, 2, \dots J\}$. Delivery order j is a specified number e_j of goods with the desired date of delivery k_j and j must transport the goods of the delivery order jointly after completion of their output. All order delivery dates may be different dates. Early and late arrivals at the distribution center incur a time penalty and late-time penalties are charged to R_j.

Different transport modes $i \in I = \{1, 2, \dots I\}$ are used for transport from the plant to the distribution center I. Transportation mode I have the same group of medium or heavy trucks and light. Vehicles are homogeneous. The mode i vehicle reflects a certain amount of transport time c_i, transport rate t_i, weight curb o_i, capacity b_i, and parameter of carbon emission. A product with a certain volume and a certain weight is a standard product. The order for delivery can be carried by multiple vehicles with various modes of transport over the same period, while several orders can also be transported by one car based on various carrying capacity and order sizes of the vehicle. The vehicles arrive at the plant and receive delivery orders completed at a fixed time each day. Every mode of transport requires enough vehicles to carry out the necessary transport tasks.

First of all, the manufacturer must specify the date of pickup from order Q_j of this order is stored in the plant after production is finished, the G_j Holding price for the delivery order j is incurred. Based on Q_j values, it is possible to determine the delivery orders should be transported at each purchase date l, $l \in L = \{1, 2, \dots L\}$. The supplier must then specify the modes of transport (denoted by N_{ji}) are chosen and the number U_{ji} of respective vehicles in N_{ji} Mode in order to transport the delivery order j. N_{ji} Shall be 1 if transport mode i is used for delivery I otherwise it shall be 0. In order to maximize transport goals, the goal of the investigated green transport planning issue is to define the optimal variant of Q_j, N_{ji}, and U_{ji}.

Let f_j and g_j Indicates the finish date of manufacture and the average daily holding level, j. h_j and r_j Refer, respectively, to the daily early and late delivery penalty rates. R_j and ω_j denote a product delivery order's volume ratio and a weight ratio j. Let K_j and C_j indicate the actual date of delivery, and the actual time of transport of the order (day) j. E_{jl} states that j collected on the light day when order is received. If so, it's 1; if not, it's 0. M_{li} and S_{li} show the number and the actual load of the M_{li} vehicles used in transport mode I on the day of pick up the l. T_l Refers to transport costs for loads selected at date l. W_{li} Refers to the carbon emissions produced for the transport loads picked at date l by transport vehicle mode my.

3.1 | Proportions 1

Objective (1) reduces the amount of the transportation costs associated with all the shipments involving the price of transport T_l, holding costs G_j, early payment H_j, and late payment R_j.

$$\min P_1(Q_j, N_{ji}, U_{ji}) = \sum_{l \in L} T_l + \sum_{j \in J} (G_j + H_j + R_j). \tag{1}$$

Objective (2) minimizes all delivery orders total carbon emissions.

$$\min P_2(Q_j, N_{ji}, U_{ji}) = \sum_{l \in L} \sum_{i \in I} W_{li}. \tag{2}$$

Reducing the objective value (1) could result in raising the objective value (2). Between these two objectives, there is a balance. The weighted sum method has been utilized, to establish the tradeoffs between various goals and converted the multiple target issues into one objective.

Green transport can be described as an environmentally friendly transport system. This category uses human power, public transport, intelligent design, and renewable energy, reduce the negative environmental impact of transport activities. The study was aimed at designing appropriate transport solutions to improve the condition of transport, which would make transport in the city environmentally friendly. The best solutions for each region to address the major problems found by the "Green Transportation Index" quality have been evaluated objectively in this case from the literature and user opinions regarding improvement options in the creation of eco-friendly transport. The possible solutions are 35 more applicable to the field of study and provide the overall guideline for the design of a green transport project for the urban city. The proposed system achieves the two objectives, there are reduce the total transportation cost and reduce CO_2 emission in smart city transportation. Figure 2 shows the proposed framework of the green transportation index.

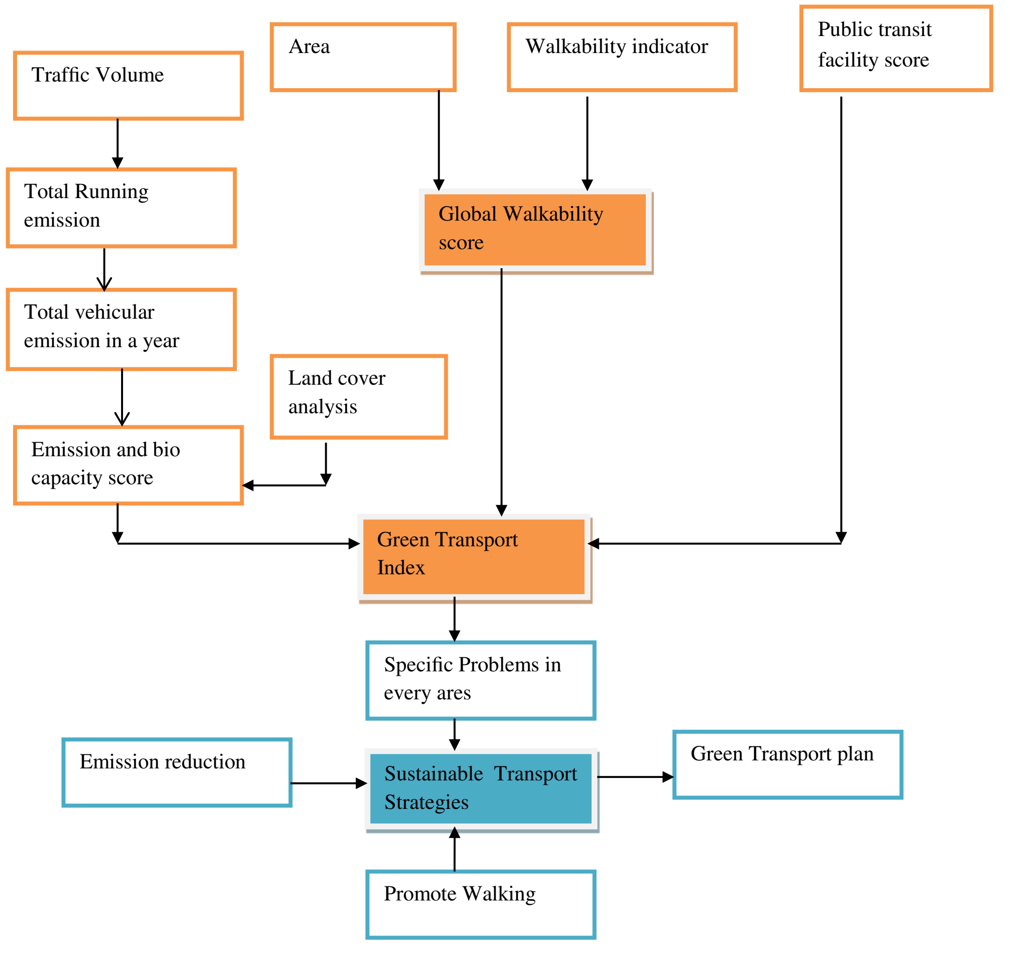

FIGURE 2 The framework of green transport index [Color figure can be viewed at wileyonlinelibrary.com]

3.2 | Proportions 2

Constraints (3) to (7) determine the terms of the two objectives

$$T_l = \sum_{i \in J} (M_{li} \cdot t_i), \tag{3}$$

$$G_j = (Q_j - f_j) \cdot g_j, \tag{4}$$

$$H_j = \max(k_j - K_j, 0) \cdot h_j, \tag{5}$$

$$R_j = \max(K_j - k_j, 0) \cdot r_j, \tag{6}$$

$$W_{li} = \sigma_{i1} \cdot M_{li} + \sigma_{i2} \cdot S_{li}. \tag{7}$$

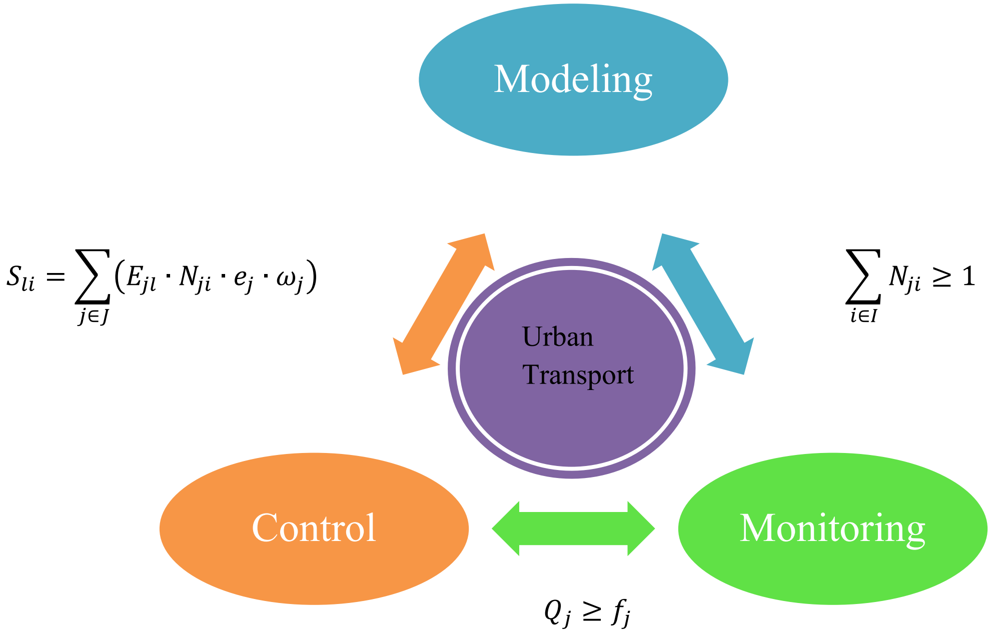

FIGURE 3 Urban transport system [Color figure can be viewed at wileyonlinelibrary.com]

Constraints (8) stipulate the collection and transportation of a delivery order j after completion of its production.

$$Q_j \geq f_j, \forall j. \tag{8}$$

Figure 3 shows the basic urban transport system. In this article, the intelligent traffic management and traffic condition real-time knowledge, possible road hazards allow traffic control centers to provide optimized routes and improve traffic quality in specific situations. Improvement of information on traffic centers can also enhance route data such as distance to destination, time, consumption of fuel, prevent traffic from dense areas or inform points of interest (car parks, fuel stations, restaurants, and so on). Other potential advantages apply to the monetary aspects Low traffic, travel times, CO_2 emissions and incidents can be accomplished by reducing essential costs. The sustainability of existing road services relates to optimum use. Traffic control stations can better handle traffic flow and provide smart advice on routes. In addition, the emission of traffic and time by adapting cars speed to the green light cycles will be improved. Sustainability problems also needed a mental shift in drivers, companies, and administrations.

Constrictions (9) and (10) ensure that each order is only collected once.

$$Q_j = \sum_{l \in L} (E_{jl} \cdot l), \quad \forall j, \tag{9}$$

$$\sum_{l \in L} E_{jl} = 1, \quad \forall j. \tag{10}$$

3.3 | Proportions 3

Constraint (11) requires that j shall be transported by one or more modes of transport

$$\sum_{i\in I} N_{ji} \geq 1, \quad \forall j. \tag{11}$$

Constraint (12) measures the time of the transport C_j of the order j.

$$C_j = \max_i (N_{ji}, c_i), \quad \forall j. \tag{12}$$

Constriction (13) ensures j have a standard shipping time for the modes of transport used to transport the delivery order.

$$C_j = \sum_{i\in I} (N_{ji}, c_i) / \sum_{i\in I} N_{ji}, \quad \forall j. \tag{13}$$

Constraints (14) and (15) guarantee that all delivery goods j must be transported.

$$\sum_{i\in I} (U_{ji} \cdot b_i) = e_j \cdot u_j, \quad \forall j, \tag{14}$$

$$N_{ji} = \begin{cases} 1 & U_{ji} > 0 \\ 0 \text{ otherwise} & \end{cases}, \quad \forall j, i\ . \tag{15}$$

3.4 | Proportions 4

(Efficient Meta-Heuristic Algorithm for Green Transportation.). Input: i, j, l.

Output: N_{ji}, $S_{li.}$

For $(i = 0)$

$$T_l = \sum_{\boldsymbol{i\in J}} (M_{li} \cdot t_i)$$

For $(j = 0)$

$$Q_j = \sum_{l\in L} (E_{jl} \cdot l)$$

For $(l = 0)$

$$M_{li} = \left\lfloor \sum_{j\in J} (E_{jl} \cdot U_{ji}) \right\rfloor$$

If

$$S_{li} = \sum_{j\in J} (E_{jl} \cdot N_{ji} \cdot e_j \cdot \omega_j),$$

Else

$$\sum_{i \in I} (U_{ji} \cdot b_i) = e_j \cdot u_j$$

End for
End for
End if
End
Return

As shown in the Algorithm 2.The actual delivery date K_j of delivery order j will be determined by the constraint (16).

$$K_j = Q_j + C_j, \quad \forall j. \tag{16}$$

Constraints (17) and (18) measure the M_{li} A number of transport vehicles in the my mode used at the pickup date l and the real S_{li} load in the M_{li} car.

$$M_{li} = \left\lceil \sum_{j \in J} (E_{jl} \cdot U_{ji}) \right\rceil, \forall l, i, \tag{17}$$

$$S_{li} = \sum_{j \in J} (E_{jl} \cdot N_{ji} \cdot e_j \cdot \omega_j), \quad \forall l, i. \tag{18}$$

Constrictions (19) to (21) built the three decision variables and two intermediate variables to be nonnegative, integer, or binary.

$$U_{ji} \in \mathbb{R}_0^+, \forall j, i, \tag{19}$$

$$K_j, Q_j \in \mathbb{Z}^+, \quad \forall j, \tag{20}$$

$$E_{jl}, N_{ji} \in \{0, 1\}, \forall j, i, l. \tag{21}$$

The mathematical model of the GUMM reduces the total CO_2 emission and total transportation cost. There are several modes of transport available, every of which depicted a type of vehicle with a certain time and the ability to transport. When to pick up completed products, the producer must decide which mode of transport is chosen for every order. The features of the choice of carbon emissions, transport mode, and pickup time the target varies, most of the issues we have with transport scheduling in literature. In this article, we propose, meta-heuristic algorithm to determine the different transport modes and CO_2 emissions. Green transport schedule consideration problem with pick-up time and selection of transport mode. There are various modes of transport available, each of which is a type of vehicle (carrier) with a certain amount of ability to transport. The proposed GUMM with the meta-heuristic algorithm achieves a better selection of transport mode with high accuracy and performance.

4 | EXPERIMENTATION AND DISCUSSION

4.1 | Performance ratio

The effectiveness and performance of a city with mobility objective, such as carbon emissions, travel time, accidents, and the extent to which innovative mobility principles such as car-sharing and cycling have been introduced. The proposed GUMM achieves better performance ratio when compared with other existing method WAVE, ICA, SUMO, CVSN, and ESMPO. Figure 4 shows the proposed GUMM performance ratio.

Table 1 shows the performance ratio of the GUMM method. The performance indicators have been identified and the transport system decision-making process assessed with the help of mathematical models and meta-heuristic algorithm.

4.2 | Prediction ratio

We classify and describe recent public urban datasets on mobility and how we can use them in the construction of mobility models or validation of the prediction results. We also provide well-known models and predictors with a mathematical model. The proposed GUMM achieves a

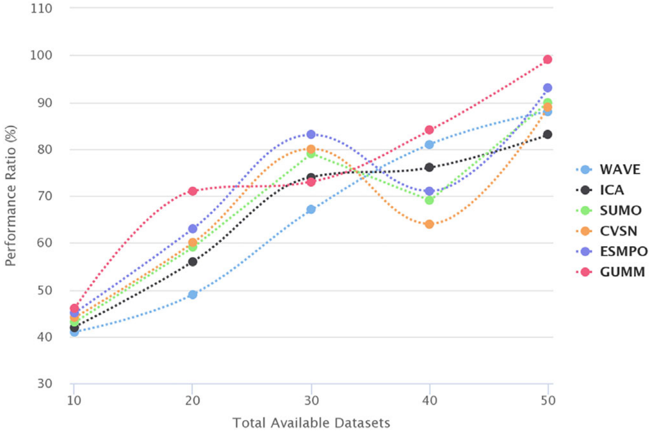

FIGURE 4 Performance ratio [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Performance ratio

Total available datasets	WAVE	ICA	SUMO	CVSN	ESMPO	GUMM
10	41	42	43	44	45	46
20	49	55	59	63	64	71
30	68	72	74	79	80	84
40	63	70	77	87	85	88
50	82	87	89	91	94	99

Abbreviations: CVSN, crowdsourcing based vehicular social networking; ESMPO, evolution-strategy-based memetic Pareto optimization; GUMM, green urban mobility model; ICA, imperialist competitive algorithm; SUMO, simulation of urban mobility; WAVE, wireless access in a vehicular environment.

high prediction ratio when compared with other existing methods. Figure 5 shows the predicted ratio of the proposed system.

The supplier must then specify the modes of transport (denoted by N_{ji}) are chosen and the number U_{ji} of respective vehicles in N_{ji} mode in order to transport the delivery order j. N_{ji} shall be 1 if transport mode i is used for delivery 1 otherwise it shall be 0. This probably helps to improve the prediction ratio as shown in the Table 2.

Table 2 describes the predicted ratio of the proposed GUMM method. Urban traffic irregularities usually result from collisions, controls protests, and other events. To predict the event in traffic management the proposed method achieves a better prediction ratio.

4.3 | Accuracy ratio

The proposed mathematical model of GUMM has high predictive accuracy. The GUMM model can greatly enhance predictive capabilities in many phenomena, from long-term mobility patterns to volumes of interaction between various regions. Figure 6 shows the accuracy ratio of the proposed approach.

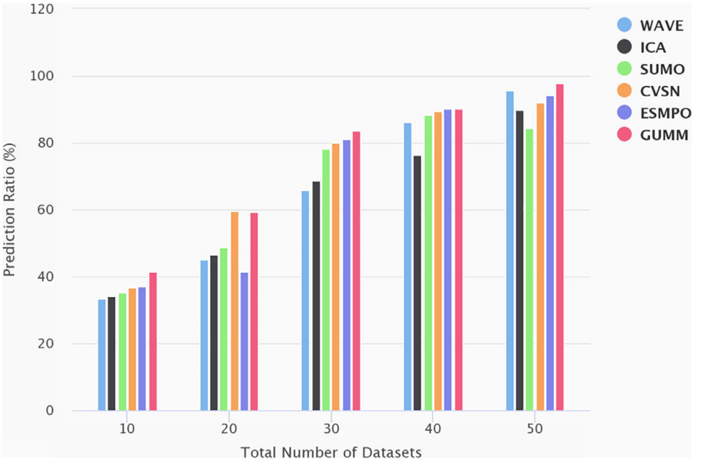

FIGURE 5 Prediction ratio [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Prediction ratio

Total available datasets	WAVE	ICA	SUMO	CVSN	ESMPO	GUMM
10	33.5	34.1	35.4	36.9	37.1	41.3
20	45.2	46.7	48.7	59.8	41.4	59.1
30	65.7	68.9	78.3	79.9	81.1	83.6
40	86.3	76.3	88.2	89.3	90.2	90.32
50	95.7	89.7	84.2	91.2	94.2	97

Abbreviations: CVSN, crowdsourcing based vehicular social networking; ESMPO, evolution-strategy-based memetic Pareto optimization; GUMM, green urban mobility model; ICA, imperialist competitive algorithm; SUMO, simulation of urban mobility; WAVE, wireless access in a vehicular environment.

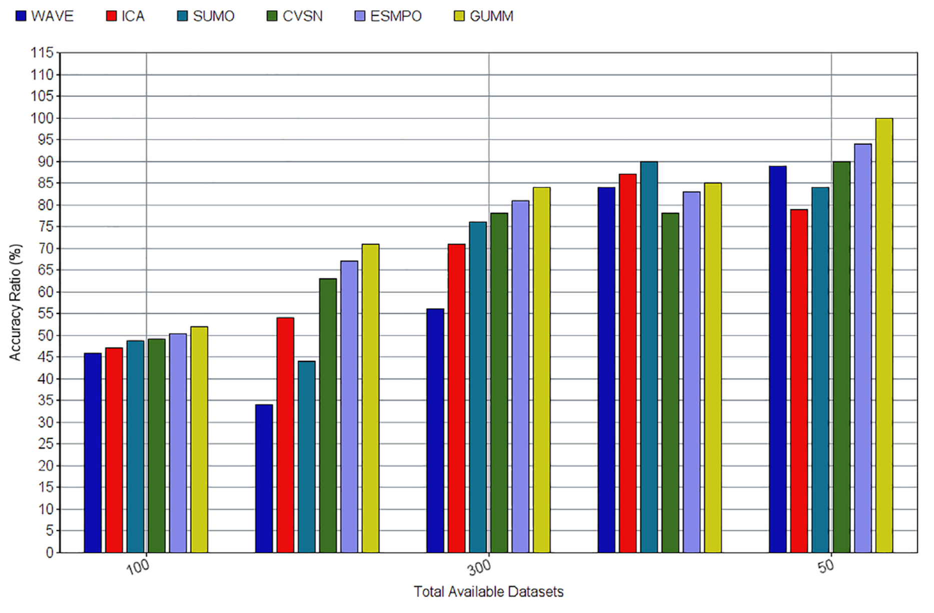

FIGURE 6 Accuracy ratio [Color figure can be viewed at wileyonlinelibrary.com]

4.4 | Computational time

The resulting trend shows that computation time decreases dramatically by minimizing the problem size. Therefore, a way to solve complexity is required to achieve high-quality solutions within a fair amount of time. The proposed GUMM takes minimum time for analyzing the traffic event in green transportation in the smart cities. Figure 7 demonstrates the computational time of the proposed system.

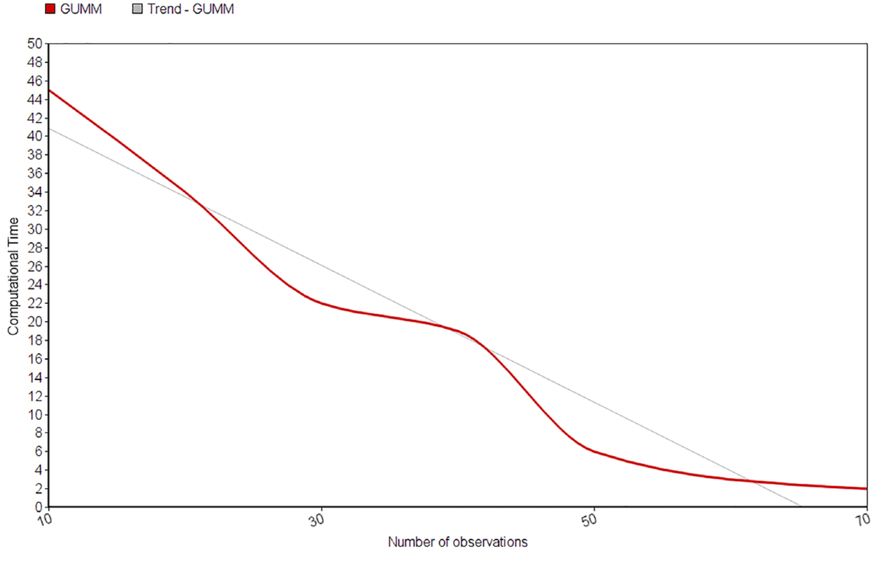

FIGURE 7 Computational time [Color figure can be viewed at wileyonlinelibrary.com]

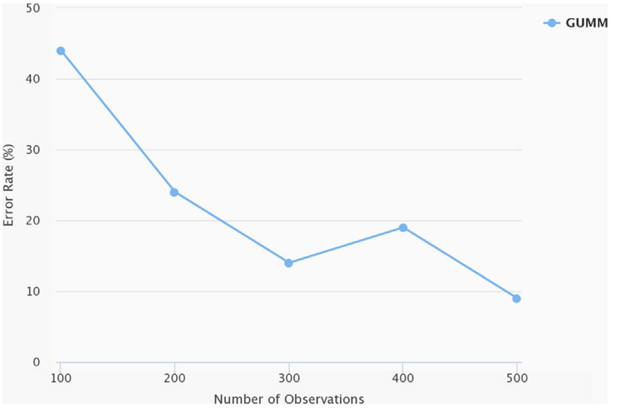

FIGURE 8 Error rate [Color figure can be viewed at wileyonlinelibrary.com]

4.5 | Error rate

Error metrics are often used to test the performance of various models of mobility and predictive algorithms. In this article, certain trips may overlap because of an error in the device or just due to the taxi driver's failure to log out after passers are dropped. Furthermore, to optimize the decomposition issue through error reduction and the regularization function to avoid overfitting. The proposed Mathematical model of the GUMM has less error ratio when compared with other existing methods. Figure 8 demonstrates the error rate of the proposed system.

The proposal of a new model for the schedule of transportation and the assignment of drivers provided an effective constructive heuristic to the problem and introduced the concept of speed control. Finally, a discussion of the discrepancy between overall transport costs and carbon emission with the green theory on transportation was eventually addressed.

5 | CONCLUSION AND FUTUREWORKS

In every country transport is an important infrastructure. This impacts economic growth greatly. By contrast to all its benefits, transport has environmental harm effects A considerable amount of greenhouse gas is released in this sector. Efficient transport planning can reduce harmful effects and boost operations of the supply chain. In this article, we proposed a mathematical model of a GUMM for green transportation in smart cities. As a manufacturing index and as an environmental sustainability index, we focused on total transportation costs and total carbon emissions. The proposed method achieves a better performance rate when compared with other existing methods.

The article contributes from various perspectives to the existing literature. First, it solved two objectives and several different features commonly found in the real-world market to order supply chain operations in green transport scheduling problem. Second, the studied problem's mathematical model has been established. Third, the optimization approach has been developed, incorporating an evolutionary strategy that can effectively deal with nonlinear integer problems with 98.55% accuracy and 97% prediction ratio.

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