

# A review of the sustainability indicators' application in vehicle routing problem

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#### **ARTICLE INFO**

Received: 6 September 2023 Accepted: 9 October 2023 Available online: 27 October 2023

doi: 10.59400/be.v1i1.221

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ABSTRACT: In today's competitive market, reducing costs and time is one of the most important issues that has occupied the minds of managers and researchers. With the expansion of industries, almost all businesses need a supply chain management system that is first able to meet the needs of customers and secondly by providing modern solutions to reduce time and cost, have the necessary efficiency to meet the challenges of the logistics industry and the supply chain. This issue is especially important in the field of supply chain management and transportation, because by reducing time and cost, manufacturers and service providers can gain a competitive advantage over competitors. Accordingly, vehicle routing issues are one of the most important issues in this field because it is directly related to the time of service or product delivery and also by optimizing the network, reduces the cost of the entire network. In this research some studies on the issue of sustainability in the transportation network have been discussed, which is a review of previous research in this field.

*KEYWORDS:* transportation; stability indices; vehicle routing problem

### 1. Introduction

Vehicle routing issues are one of the most important issues in this field because they pay special attention to the time and cost of providing a product or service from the perspective of the customer and the company<sup>[1]</sup>. One of the attractions of transportation, which is one of the major and important parts of any country's economy, is its economic value in the development of the country or its effectiveness in the profitability of companies and organizations. The main purpose of transportation planning is to minimize the cost of transportation of goods and materials between the two levels of producer and consumer so that the demand of each consumer is satisfied by producers. The goal of Vehicle Routing Problem (VRP) is usually to determine the optimal route for vehicles so that each route includes at least one vehiclestarting and ending at the relevant warehouse—in a way that the needs of all route customers are met, each customer is met at most once, and also all operational restrictions are met, and the cost of public transportation is minimized. The VRP Return Vehicle Routing Problem is an extension of the Capacity Vehicle Routing Problem (CVRP). In VRP, customers are divided into two groups: return line (delivery) and return line (receipt of goods). The departing line customer needs a number of goods to be delivered, and the return line customer needs to receive some goods from it. Since CVRP is an NP-hard problem, the Vehicle Routing Problem with Backhauls (VRPB) problem is also defined as an NP-hard problem. This issue seeks to replace a profitable movement instead of an empty return of vehicles to the central depot, meaning that it reduces distribution costs by utilizing the unused capacity of vehicles on return.

## 2. Statement of the problem

The term supply chain was introduced in the world in the late 1980s and was practically used around 1990. Today, the need for this topic in the fields of industry and management has received more attention from scholars and academics. And it can be said explicitly that this branch of science has become a tool for creating competition in global markets. It should be noted that logistics and supply chain management has always been considered as a strategy to reduce costs and increase speed, quality, and services with the aim of achieving competitive advantages in business considered by manufacturers, distributors, customers, and stakeholders in general and along with the increasing advancement of technology, in addition to coping with energy shortages, reducing casualties in accidents and observing economic savings, supply chain management in the field of transportation is also of great importance, and fortunately, this approach continues to grow<sup>[2]</sup>. Optimization problems can be divided into two types in terms of the number of objective functions and optimization criteria: single-objective optimization problems, the purpose of solving the problem is to improve a single performance index, where the minimum or maximum value of it fully reflects the quality of the response obtained. But in some cases, it is not possible to score a hypothetical answer to an optimization problem by relying on just one indicator.

With the expansion of the market today, almost all businesses need a supply chain management system that is not only able to meet the needs of customers and be cost-effective, but also to have modern solutions to the current challenges of the logistics industry and supply chain. In fact, not paying attention to any of the five components of ergonomics will cause problems and limitations in one or more of the main pillars of sustainable development. The purpose of this study is to review of investigating the problem of vehicle transportation based on sustainability indicators.

# 3. Research methodology and review of relevant literature

Research is based on library studies (literature review and previous research work). For this research, process about 30 papers during 2014–2021 has been extracted from different journals with these specific keywords: transportation, stability indices, and vehicle routing problem which we classified them into four classes:

- The researchers try to focus on all three indicators of sustainable development (environmental, social, and economics).
  - Because of the importance of economics indicator, the other classes are based on this indicator:
- Some researchers try to focus on just economics indicator of sustainable development.
- Some researchers try to focus on economics and social indicators of sustainable development.
- Some researchers focus again on two indicators of sustainable development (economics and environmental).

In order to gradually face the complexity of the proposed topic in the research stages, it is better to break the research into several stages and increase its complexity in each stage, so that the structured approach to the research complexities allows the results of each stage to be used in the next stage. In this regard, first, an optimization model for the closed-loop supply chain, in which the manufactured products are sent directly from the manufacturers to the customers, is presented. Then, if possible, nonlinear programming models are transformed into a linear model and precise linear problem-solving methods are used. Nastern et al. studied the subject "Assessment of indices of social sustainability by using analytic network process"<sup>[3]</sup>. In the 1960s and 1970s, in addition to the importance of environmental pollution, it became clear that environmental problems are closely related to the relationship between humans and the environment, so the acceptance of traditional models of growth and development was questioned<sup>[4]</sup>. Three aspects of the sustainable development issue were introduced by Elkington<sup>[5]</sup> in 1998: the economic aspect, the environmental aspect, and the social aspect. It is also used for the first time by Garetti and Taisch<sup>[6]</sup> on sustainable development in transportation with the aim of increasing profitability (reducing costs), reducing environmental impact, and increasing social responsibility.

Social responsibility is the willingness of an organization to consider ethical, social, and environmental considerations in organizational decisions and being accountable for the impact of its activities and decisions on society and the environment.

In fact, the goal of implementing green supply chain management in business activities is to improve both economic and environmental performance simultaneously. Indeed, economic improvement is also reflected in reduced material purchasing costs, reduced energy consumption, and reduced waste emissions<sup>[7]</sup>. In addition to direct financial benefits such as cost savings and increased profits, producers may shift from green activities to other benefits such as being prepared to produce new products and adhering to new regulations to reduce consumption or pollution. As a result, its benefits extend to all parts of the organization.

The material benefits of green supply chain management also include helping the environment, lower costs for suppliers, lower costs for the producer, lower cost of ownership for the customer, and less consumption of resources for the community<sup>[8]</sup>. Green supply chain management activities are a tool for environmental protection and the best perspective as an inter-organizational activity that allows supply chain members to work together throughout the chain and also protect the environment<sup>[9]</sup>.

Some researchers consider green supply chain management activities as green purchasing, green design, repair, recycling, and reusing of used products and cooperating with customers and green suppliers<sup>[10]</sup>. In other words, there is a positive and direct relationship between the green supply chain and organizational performance.

Increasing sustainability in business approaches and research over the years has become increasingly important as a result of the rapid depletion of natural resources, wealth disputes, and corporate social responsibility. This issue has manifested itself in the development of legislation, the accountability of organizations, more attention to educational managers in sustainable management and the development of the theory of support for sustainable management decision-making<sup>[11]</sup>.

### 4. Research categories based on the index

In some research, the researchers try to focus on all three indicators of sustainable development (environmental, social, and economics), such as Ghezavat et al.<sup>[12]</sup> and Paydar et al.<sup>[13]</sup>.

The aim of the study conducted by Mojtahedi et al.<sup>[14]</sup> was to introduce a new coordinated framework for a practical and efficient routing problem with respect to the triple endpoint of sustainability. The multifunctional CSWM functions used in this study address financial, environmental, and social issues in order to create the problem of sustainable vehicle routing by considering a fleet of heterogeneous vehicles operating across the multi-layered logistics network for optimization purposes. The development and application of fully adaptive memory engineering (AMSEO) has been introduced and shows that it performs significantly better than simulated annealing (SA) as well as social engineering optimizer (SEO) itself. Finally, it is important to save on total waste disposal costs that can be achieved by increasing recycling (identified by framing the logistics problem at several levels). The main findings are practical solutions using sustainability goals for CSWM and further application and development of AMSEO in routing optimization<sup>[14]</sup>.

Dundar et al.<sup>[15]</sup> have discussed the problem of sustainable vehicle routing, which includes economic, environmental, and social concerns. As far as we know, this is the first literature review to focus on sustainable practices in urban navigation. The first purpose is to examine the scope, objectives, solution methods, and types of data in the articles under review. The second goal is to analyze the indicators used in the proposed quantitative models and how they relate to sustainability and green standards in the field of vehicle routing. The ultimate goal of reviewing study findings is to identify gaps relevant in the literature and suggesting topics for future research. One of the key findings of this study is that the economic dimension is a prominent driver among the three pillars of sustainability. Researchers have paid less attention to environmental and social dimensions. Social indicators have been shown to be the least sub-dimension of sustainability. It is thought that the results of this study help researchers and professionals to learn more about sustainability methods and models or green practices economic, environmental and social criteria used and consequences<sup>[15]</sup>.

In the paper of Mirzabaghi et al.<sup>[16]</sup>, the aim is to introduce the problem of stable routing of heterogeneous vehicles in a network with direct and reverse flows, where various economic, environmental and social factors are considered in the form of a mathematical model of two-objective linear integer programming. The purpose of the problem is to design service routes and determine the optimal speed of transportation in such a way that on the one hand the amount of fuel consumed and consequently the pollution caused by the transportation process is minimized and on the other hand in order to create satisfaction between drivers, the workload of different means of transport in terms of duration of activity is balanced. To estimate the amount of fuel consumed, a comprehensive function has been used in which the amount of fuel consumed is a function of the distance traveled, as well as the speed, load and technical characteristics of the vehicle. Pareto points analysis also shows that by increasing the fuel cost by about 1%, the longest tour can be reduced to even more than 20% and the scatter between operating times of different cars can be reduced by up to 15%. Also, this scattering can be reduced by up to 25% by increasing fuel consumption by 3%<sup>[16]</sup>.

In another paper, a new multi-objective optimization model is presented based on the problem of classical facility location, which considers socio-economic and environmental goals. The first objective function minimizes the cost. The second objective function minimizes customer service and the third objective function minimizes  $CO_2$  emissions. In this algorithm, the facility capacity is considered. Finally, a numerical example is presented to show the application of the model and the model code is written and solved in GAMS. **Figure 1** shows the distribution of environmental, social and economic articles in the year.



Figure 1. Dispersion of articles environmental, social, and economics by year.

In some research, the researchers try to focus on just economic indicators of sustainable development, such as Fernandez et al.<sup>[17]</sup>, Jalilian et al.<sup>[18]</sup>, and Fathi and Dehghanian<sup>[19]</sup>.

Lak et al.<sup>[20]</sup> studied a step towards examining and solving one of the key issues in transportation issues, to serve a certain number of customers with different demands and restrictions that apply to different vehicles so that costs are minimized and capacities are not violated. In order to validate the model, they solved it in small dimensions with Lingo software and compared it with the results obtained from the real data of the organization and then solved the model.

Since the problem of vehicle routing is in the category of NP-Hard problems, a mathematical solution with Lingo software in small dimensions and in large dimensions that mathematical software could not solve the proposed genetic meta-heuristic algorithm (GA) was used. In order to validate the model solution, the results of the model solution with Lingo software were compared with the results of the algorithm and observed that there is no significant difference between these results. As a result, solving the model of the route and sequence of sending customers' loads for each of the vehicles was determined so that the capacity of the vehicles is not violated and all customers are served<sup>[20]</sup>.

In another research, the issue of vehicle routing is investigated in which a fleet of vehicles is engaged in serving a group of customers in a period of time determined by customers, so that the demand of customers is fuzzy. Therefore, vehicles should be routed in such a way as to observe the time window, the total duration of the route, the extra duration of the route due to failure, and also the amount of fines resulting from the soft time window is minimized<sup>[21]</sup>.

In the next research, the multi-depot vehicle routing problem (MDVRP) and the near-open mixed vehicle routing problem (NOMVRP) with the assumption of a heterogeneous fleet are considered. The goal is to minimize the total cost of customer service. To deal effectively with this problem, a new mixed-integer programming (MIP) model as well as a new hybrid metallurgy are proposed. In addition, the analytic hierarchical process is used in the hybridization of the genetic algorithm<sup>[22]</sup>.

The next paper addresses a new issue of vehicle routing that has arisen in an urban area where multiple carriers operate and some of their customers are requesting services for more than one shipping company. This is done with the aim of reducing overall operating costs in a framework of cooperation between customer service companies. Alternative mathematical programming formulas are proposed for the problem solved by a branching and cutting algorithm. Computational results evaluate the effectiveness of formulas in different sets. In addition, in order to estimate the savings due to cooperation, the optimal solutions were compared with the obtained and independent solutions<sup>[17]</sup>.

In another study, the transport of hazardous materials with the problem of vehicle routing is modeled using a heterogeneous fleet of trucks. Multi-objective version. The problem of vehicle routing has not been studied as much as its single-objective version. Two solution methods are proposed: an algorithm based on multi-objective neighborhood dominance and an  $\varepsilon$ -constrained meta-exploratory algorithm, both based on neighborhood search. Comprehensive comparisons between solution presentation methods are performed using multi-objective criteria. The results show that the use of an algorithm based on functional mastery offers better in terms of approximate Pareto front quality than the use of  $\varepsilon$ -constraint method<sup>[23]</sup>. **Figure 2** shows the distribution of economics articles by year.



Figure 2. Dispersion of articles economics by year.

In some research, the researchers try to focus on two indicators of sustainable development (social and economics), such as:

In the study, Goodarzi et al.<sup>[24]</sup> addressed the problem of cross-vehicle vehicle routing, hich considers truck planning, splitting delivery, and delivery orders with time windows at supplier and retailer locations, while it optimizes the opposite goals (i.e., cost efficiency and accountability). The goal is to minimize the total operating cost and the sum of the maximum early and late. A dual-purpose linear programming model and a new integer are proposed, and a multi-purpose evolutionary algorithm is proposed to solve the problem. The numerical results show the effectiveness of the proposed algorithm compared to the two multifunctional meta-heuristic algorithms (namely the non-dominant genetic algorithm (NSGA-II) and the Pareto Archived Evolution Strategy (PAES)). Goodarzi et al. also report the findings of a hypothetical case study in a retail chain in Houston, Texas<sup>[24]</sup>.

In the article by Khorsi et al.<sup>[25]</sup>, one of the main logistical decisions in times of crisis, namely routing and the timing of vehicles for the distribution of resources to the nearest points, has been considered. For this purpose, a dynamic mathematical, multi-commodity, multi-warehouse, multi-table planning model has been developed under uncertainty conditions, which simultaneously includes several important features of real-world problems. The multi-period planning used allows planners to update logistics plans in the event of any changes in parameters, taking into account new events and previous actions, and to improve the efficiency of planning. To evaluate the likelihood and efficiency of the proposed model, a case study from the metropolis of Tehran is presented. The findings show the applicability of the expressed model to solve real problems<sup>[25]</sup>. **Figure 3** shows the distribution of social and economic articles in the year.



Figure 3. Dispersion of articles social and economics by year.

In some research, the researchers also preferred to focus on two indicators of sustainable development (environmental and economics), such as Asadollahi<sup>[26]</sup>, Safaei and Jafari<sup>[27]</sup>, and Navidi et al.<sup>[28]</sup>.

Costs in Green Vehicle Routing and Planning have been minimized with the aim of minimizing carbon dioxide (CO<sub>2</sub>) emissions in logistics systems by better planning vehicle fleet deliveries. In the paper of Matos et al.<sup>[29]</sup>, GVRSP considers heterogeneous vehicles and presents a mathematical formula for describing the problem and a hybrid algorithm that combines iterated local metaheuristic search (ILS), random variable downtrend (RVND), and an accurate set adjustment method. The results were compared with the developed case and showed that the proposed approach has a strong performance<sup>[29]</sup>.

In the article by Noruzi et al.<sup>[30]</sup>, with regard to the problem of vehicle routing, with the aim of reducing energy consumption and travel times, they determined the optimal routes for a fleet of vehicles so that the travel time between points (customers) to the time of day at which point travel the beginning is dependent. Therefore, a new mathematical model has been proposed to reduce the path time and the meta-heuristic method of colonial competition has been used. Therefore, a number of problems are considered by considering the variable travel velocities in different time intervals; and then, to show the efficiency of the designed algorithm, the obtained results are compared with the particle mass optimization (PSO) method<sup>[30]</sup>.

In another research, a new model of the green inventory routing problem with a heterogeneous fleet is presented. The proposed model considers minimizing fuel consumption, combined fleet costs, routing costs, and inventory. Due to the NP-hard nature of the problem, a meta-heuristic algorithm based on the quantum heuristic algorithm is proposed to solve the problem. In order to evaluate the proposed algorithm, the results are compared with the results of accurate problem-solving and the basic algorithm, and their results indicate the proper performance of the proposed algorithm<sup>[31]</sup>.

In Asadollahi's research<sup>[32]</sup>, by presenting a mathematical model, a logistics model for crisis logistics planning has been discussed. This model includes the designation of relief centers as well as the routing and transportation of vehicles in order to provide the goods needed by the needful and injured people in the event of disasters. Obviously, in the event of accidents, shortening the relief time has a very important role in reducing casualties and disabilities caused by these accidents, so the purpose of this model is to minimize the time of arrival of vehicles to the affected areas and take into account the costs of location, finding warehouses and transporting medicine or injured people in the relief network; and the second goal is to reduce the environmental impact of crisis safety services.

In a study by Ghassami et al.<sup>[33]</sup>, a combination of car routing problems called car routing problems with time window and random demand was investigated. The difference between previous articles and

this article is that, competitors compete with each other to meet the demands of customers in a particular industry. These problems also seem to occur in real life. In most real environmental problems, customers realize the greatest demand for a vehicle that is timely and faster than other competitors. The objective function is to maximize the profit from the sale of goods to customers. Solving the research model on several trivial problems is done using exactly GAMS software<sup>[33]</sup>. **Figure 4** shows the distribution of environmental and economic articles by year.



Figure 4. Dispersion of articles Environmental and Economics by year.

Totally, the first dimension (economic) is related to the financial partnership of firms with partners, employees, and the internal community. Financial and economic factors can be categorized into four areas: strategic factors (such as cost reduction), maintaining financial performance, tactical aspects (such as costs), and operational factors (cycle time, customer reference, and energy consumption)<sup>[34]</sup>. The second dimension (environmental dimension) refers to the aspects of internal environmental management and the issues of conservation of external natural resources. In this regard, the growth of environmental issues and various pollutants in the development of industries has led to the emergence of the concept of green supply chain management. In recent years, companies have implemented various control programs and programs to ensure that suppliers are able to provide quality materials and services as well as meet environmental standards. Green supply chain management is usually in the form of monitoring performance and trends, including transportation based on environmental performance, that meet relevant environmental standards<sup>[35]</sup>. The third dimension (social dimension) includes qualitative and ethical issues related to risk management, health and safety issues and employment issues. In this context, corporate social responsibility can be defined as "voluntary legislation by organizations on social and environmental issues in their business operations and relations with other stakeholders". Organizations are increasingly realizing that their activities in purchasing and chain management are strongly influenced by their reputation and long-term success. Organizations are responsible for promoting and protecting the environment, health, and safety of workers and employees<sup>[36]</sup>.

The following research can also be mentioned:

Taghipour et al.<sup>[37]</sup> studied "Risk analysis in the management of urban construction projects from the perspective of the employer and the contractor".

Mahboobi et al.<sup>[38]</sup> discussed "Assessing ergonomic risk factors using combined data envelopment analysis and conventional methods for an auto parts manufacturer", occupational injuries are currently a major contributor to job loss around the world.

Taghipour et al.<sup>[39]</sup> studied "The impact of ICT on knowledge sharing obstacles in knowledge management process (including case-study)".

Khalilpour et al.<sup>[40]</sup> studied "The impact of accountant's ethical approaches on the disclosure quality of corporate social responsibility information an Islamic perspective in Iran".

Mirzaie et al.<sup>[41]</sup> studied "The relationship between social bearing capacities with conflict as a result, in the perception of the visiting historical sites".

Alamdar khoolaki et al.<sup>[42]</sup> studied "Effect of integrated marketing communication on brand value with the role of agency's reputation (including case study)".

Taghipouret et al.<sup>[43]</sup> studied "A survey of BPL technology and feasibility of its application in Iran (Gilan Province)."

Seddigh Marvasti et al.<sup>[44]</sup> studied "Assessing the effect of the FRP system on compressive and shear bending strength of concrete elements."

Jalili et al.<sup>[45]</sup> studied "Comparative study of Khaje Rashid al-Din views on Rab-e Rashidi Islamic Utopia and Kevin Lynch ideas."

Taghipour et al.<sup>[46]</sup> studied "Insurance performance evaluation using BSC-AHP combined technique."

Rezvani et al.<sup>[47]</sup> discussed "The design of high-rise building with ecological approach in Iran (Alborz Province)".

Taghipour et al.<sup>[48]</sup> studied "The identification and prioritization of effective indices on optimal implementation of customer relationship management using TOPSIS, AHP methods".

Taghipour and Yazdi<sup>[49]</sup> studied "Seismic analysis (non-linear static analysis (pushover) and nonlinear dynamic) on cable-stayed bridge".

Taghipour et al.<sup>[50]</sup> studied "Investigating the relationship between competitive strategies and corporates performance (case study: Parsian Banks of Tehran)".

Taghipour and Moosavi<sup>[51]</sup> studied "A look at gas turbine vibration condition monitoring in region 3 of gas transmission operation".

Azarian and Taghipour<sup>[52]</sup> studied "The impact of implementing inclusive quality management on organizational trust (case study: education)".

Mohammadi et al.<sup>[53]</sup> studied "Investigating the role and impact of using ICT tools on evaluating the performance of service organizations".

Abdi Hevelayi et al.<sup>[54]</sup> studied "Predicting entrepreneurial marketing through strategic planning (including case study)".

Khorasani and Taghipour<sup>[55]</sup> studied "The location of industrial complex using combined model of fuzzy multiple criteria decision making (including case study)".

Taghipour et al.<sup>[56]</sup> studied "Risk assessment and analysis of the state DAM construction projects using FMEA technique".

Hoseinpour et al.<sup>[57]</sup> studied "The problem solving of bi-objective hybrid production with the possibility of production outsourcing through Imperialist Algorithm, NSGA-II, GAPSO Hybrid Algorithms".

Taghipour and Ahmadi Sarchoghaei<sup>[58]</sup> studied "Evaluation of tourist attractions in Borujerd County with emphasis on development of new markets by using Topsis Model".

Taghipour et al.<sup>[59]</sup> studied "Analysing the effects of physical conditions of the workplace on employee's productivity (including case study)".

Taghipour et al.<sup>[60]</sup> studied. "Evaluation of the relationship between occupational accidents and usage of personal protective equipment in an auto making unit".

Baghipour Saramiet et al.<sup>[61]</sup> studied "Modeling of nurses' shift work schedules according to ergonomics: A case study in Imam Sajjad(As) Hospital of Ramsar".

## 5. Conclusion

Since the philosophy of producing goods is to sell and send them to customers and meet their needs, every industry has to do logistics output and take out and send goods from the company efficiently to reduce time and cost and have the necessary efficiency for the challenges of the logistics and supply chain industry. Therefore, this issue is especially important in the field of supply chain and transportation management because by reducing time and costs, manufacturers and service providers can gain a lot of competitive advantage over competitors. In this research, while considering sustainability indicators, it was attempted to efficiently evaluate the vehicle routing problem in order to provide a comprehensive research balance for use in all industries and companies while maintaining balance. Therefore, by extending the results of this research to other sectors, all transportation fleets across the country can use the results of the present study to improve their transportation program.

## **Conflict of interest**

The author declares no conflict of interest.

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