

Recent Advances for the Development of Sustainable Transport and Their Importance in Case of Global Crises: A Literature Review

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Abstract: The 21st century is a time of rapid development, marked by technological advances, globalization, and international cooperation. It is also a period that has witnessed numerous global crises. In light of recent events, such as the migration crisis, the COVID-19 pandemic, and the escalation of the conflict between Ukraine and Russia, it is crucial to consider how to ensure economic stability and enhance the security of the transportation sector in the face of emerging threats. The goal of this publication is to identify the latest solutions in sustainable transportation development and to highlight their relevance in the context of potential global crises. To achieve this, a systematic review of the current research on transportation industry innovations was conducted using 4 different databases, yielding 492 results. From these, 223 publications were selected for analysis based on established criteria. The selected transport solutions were grouped into specific categories, and then their relevance in the context of global crises was discussed. The findings highlighted key solutions essential for economic stability and transport sector safety in potential crisis situations, while also pointing to further research directions. Additionally, they offer actionable concepts for transport organizers to promote a more resilient and sustainable flow of passengers and goods in anticipation of future crises.

Keywords: sustainable transport; transport development; modern solutions; global crises; military conflicts; COVID-19 pandemic; climate crisis; migration; literature review

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1. Introduction

The modern world remains exposed to a variety of threats, which, as the past decades have shown, can lead to serious global crises. The 21st century is undoubtedly an era of profound transformation and rapid development, with technological advances, economic globalization, and international cooperation at the forefront [1,2]. However, it is also a time marked by numerous global crises with diverse origins [3–5]. For instance, in 2008, the global financial and banking crisis stemmed from the collapse of the mortgage market in the USA [6]. In 2015, Europe faced significant challenges due to the sudden influx of migrants and refugees [7]. In March 2020, the World Health Organization (WHO) declared the COVID-19 pandemic, which disrupted all aspects of life and shook the global economy [8]. The 21st century has also been marked by ongoing military crises, as evidenced by the armed conflict between Ukraine and Russia [9], as well as continued geopolitical tensions in the Middle East [10]. These challenges are further intensified by ongoing environmental degradation and climate system disruptions, which negatively impact human health, the economy, and society [11,12].

Given the recent crises, it is essential to explore how to ensure the stability and security of the global economy in the face of new potential threats. One of the most important sectors significantly affecting the daily lives of billions of people worldwide is transport

[13]. However, it is also responsible for a substantial portion of greenhouse gas emissions, which exacerbate the climate crisis. Therefore, developing sustainable transport, which balances efficiency, low emissions, and minimal environmental impact, has become a key challenge for the modern world. Recent years have seen rapid development of technology and innovative solutions aimed at transforming the transport sector into one that is not only more environmentally friendly but also more resilient to disruptions, such as a future pandemic or another global crisis [14]. Electromobility, infrastructure development, intelligent transport systems (ITS), and innovative approaches to logistics and public transport are just some of the directions in which modern transport is evolving. However, the implementation of these solutions depends on various factors, such as government policies, technology availability, and international cooperation. Equally important is to ensure that these innovations can be effectively applied and have practical uses during crises [15].

The purpose of this publication is to identify the latest solutions in sustainable transport development and to highlight their relevance in the context of potential global crises. This study is based on two key research questions:

- What solutions related to sustainable transport development are described in the latest scientific research?
- What is the significance of recent advances in transport solutions in the context of potential global crises?

This article presents a systematic review of current research on transport industry innovations, categorizing these solutions and discussing their importance in the context of possible global crises. The findings not only highlight key solutions for ensuring the stability of the economy and the transport sector during crises but also suggest future research directions focused on developing strategies to improve security in the face of potential threats. Furthermore, these findings provide transport organizers with proposals for practical solutions that could help achieve a more resilient and sustainable flow of passengers and goods in the event of future crises.

The article is structured into several sections. Following the introduction, Section 2 presents the theoretical framework, which outlines the categorization of modern transport solutions and the classification of contemporary global crises. This section also defines the concept of 'sustainable transport' and explains its principles. Section 3 describes the systematic literature review methodology used in the study. Section 4 presents the results of the analysis of the selected body of literature. Finally, Section 5 concludes with a summary of the practical and theoretical contributions of the study, along with a discussion of its limitations and potential directions for further research.

2. Theoretical Framework: Definitions and Classifications

2.1. Classification of Modern Solutions in Transport

Conducting a review of research on the latest advances in the area of sustainable transport development in the context of their importance for potential crises requires first and foremost considering the theoretical frameworks related to modern transport solutions. These solutions can be defined as a set of methods, tools, technologies, or strategies for moving people or goods from one place to another. They may encompass various aspects of transport operations, such as infrastructure, management systems, technology, and the organization of logistics processes [16,17].

The literature provides numerous examples of solutions that have been successfully implemented in transport and widely embraced by society [18–20]. However, in an era of rapid technological advancement—where artificial intelligence (AI), advanced automation systems, the Internet of Things (IoT), and Big Data technologies [21,22] are increasingly influential—the emergence of new innovations is inevitable. Modern innovations, such as autonomous vehicles, unmanned aerial vehicles (UAVs) [23], and intelligent traffic management systems, are continually transforming the transport sector, making it more efficient, safer, and greener [24–26]. Research in the area of transport system models

(TSMs) is also worth noting, as they not only can reduce risk but also increase evacuation preparedness in the event of disastrous events [27]. The classification of these modern transport solutions is not strictly defined and continues to evolve as new technologies emerge and research advances. Given the current state of knowledge, the classification in Figure 1 can serve as a useful framework.

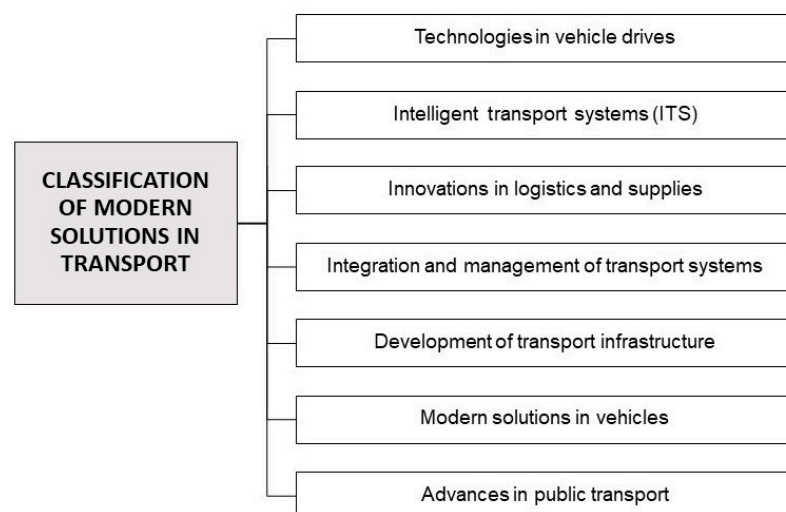


Figure 1. Adopted classification of modern transport solutions.

Recent research results show that vehicle propulsion technology is progressing rapidly, especially in the areas of hybrid (HEV and PHEV) and fully electric (BEV) drivetrains [28,29]. Work is also advancing on autonomous vehicles—those capable of driving and making decisions without human input [30]. Many publications focus on intelligent transport systems (ITS), including traffic management systems [31,32] and advanced technologies that assist with navigation and provide information to road users [33,34]. Innovation in logistics and delivery is also an active area of research, with projects exploring the use of UAVs [35] and autonomous trucks for parcel delivery [36]. Attention is also being paid to the integration and management of transport systems, such as MaaS (Mobility as a Service) platforms [37], real-time public transport management systems [38,39], and smart car parks [40]. A crucial component for the comprehensive development of the transport sector is the supporting infrastructure. This includes research on electric vehicle charging stations, sensors for smart transport systems [41], and integrated transfer hubs [42]. A significant body of literature also addresses modern vehicle technologies, such as the connected car, which enables two-way communication with systems outside the vehicle [43], as well as a range of innovations in advanced driver assistance systems (ADAS) [44]. Another important category includes public transport solutions, particularly efforts toward autonomous urban transport [45] and the implementation of on-demand transport systems [46,47]. Progress is also being made on smart bus stops and stations [48,49].

In this section, specific examples of transport innovations are linked to the identified solution categories, based on a comprehensive literature review. The analysis of research progress considered the alignment of these solutions with the principles of sustainable transport and their importance in the face of potential global crises.

2.2. Characteristics of Global Crises

Before reviewing the research, it is important to establish a theoretical framework that outlines the characteristics of undesirable phenomena, such as global-scale crises. In the literature, the term ‘crisis’ is defined in various ways. Frazmand [50] provided a basic definition, describing a crisis as an undesirable event resulting from natural, technological, or man-made causes. A crisis is also characterized by widespread negative consequences that can affect entire communities or regions [3,4]. Rodriguez et al. [51] further explained that a crisis occurs when fundamental values, such as safety, security, health, or wealth, are threatened.

Given these definitions, a global crisis can be understood as a situation where problems or threats have an international reach, impacting multiple countries and societies at once. Such a crisis has the potential to destabilize the economy, public health, politics, the environment, or other critical areas on a global scale. It is also emphasized that the recovery period following a crisis can be lengthy and may require coordinated efforts and international cooperation [52,53]. Global crises can be classified in different ways, depending on their causes and the areas they affect. For the purposes of this study, the classification was based on Borca et al. [54], Gundel [55], and Sawada [56], with additional consideration given to military crises, reflecting the geopolitical tensions witnessed in recent years across many regions [57,58] (Table 1).

Table 1. Adopted classification of global-scale crises.

Type of Crisis	Description	Example
Economic crisis	International economic problems that impact the stability of markets, nations, and societies.	Global financial crisis (2008–2009) [6,59]
Environmental (ecological) crisis	Threats to ecosystems and human health caused by environmental pollution, climate change, and overexploitation of natural resources.	- Global temperature rise [60] - Increasing frequency of extreme weather events [61]
Health crisis	Public health threats from widespread diseases, limited access to healthcare, or events, such as pandemics, epidemics, and natural disasters.	COVID-19 pandemic (2020) [62,63]
Social crisis	Disruptions in societal functions, such as mass protests, social tensions, growing inequality, or challenges to social integration, leading to destabilization and conflict.	Migration crisis in Europe (2015) [7,64]
Military crisis	Armed conflicts or the threat of military force destabilizing regions and having global consequences.	- Armed conflict between Ukraine and Russia (2022) [9] - Tensions between Iran and Israel (2024) [65]

Additionally, in order to deepen the characterization of the types of crises considered, a comparative analysis was conducted, which identified the symptoms that distinguish a specific crisis from others and showed the possible disruptions that these events may cause in the transport sector (Table 2).

Table 2. Comparison of crisis types and their impact on transport.

Type of Crisis	Distinguishing Symptoms	Impact on the Transport Sector
Economic crisis	- Sharp decline in market values and asset prices, and an increase in unemployment and inflation - Reduction in production and decline in investment and consumption - Bankruptcies, financial problems, and falling incomes at the corporate and individual levels	- Lower demand for travel due to costs [66] - Decrease in freight transport volumes [67] - Society’s shift toward public transport [68] - Reducing household expenditure on transport [69]

Environmental (ecological) crisis	• Includes degradation of natural resources (air, water, and soil) • Threat to human health from climate change, smog, and environmental pollution • Visible in the form of damage to the natural environment (forest fires and species extinction) • Related to natural processes (e.g., global warming).	• Limitations on the availability of raw materials for vehicle production [70] • Growing demand for more ecological forms of transport [71] • Rising prices of conventional fuels [72]
Health crisis	• Directly affects the health of the population • Sharp increase in demand for medical services • Rapid spread of diseases (epidemics and pandemics) • The need to apply preventive measures (quarantine and personal protective equipment)	• Decrease in demand for passenger transport, especially public transport [15] • Declining interest in tourist trips [13] • Change of preferences regarding the choice of means of transport [73] • Disruptions in global supply chains and changes in the structures of transported goods [74]
Social crisis	• Destabilizes basic social structures • Weakens the sense of collective identity and social ties • Provokes mass reactions (protests, strikes, and social movements) • Causes social transformation, often influencing subsequent generations	• Declining demand for travel due to safety concerns [75] • Problems with ensuring the safety of transport infrastructure [76] • Inequality in access to transportation [77]
Military crisis	• Direct threat to the lives of the population as a result of military operations • Includes the use of armed forces (troops, weapons, and equipment) • Causes physical destruction of infrastructure • Results in the declaration of martial law and mobilization and in taking action at the state level	• Destruction of transport infrastructure [78] • Air and sea space restrictions [79,80] • Suspension of international connections [81] • Threat of attack on transports [82]

It is difficult to classify crises in a clear and objective manner. Each crisis may have unique characteristics and varying levels of impact. Additionally, crises often have multiple interconnected causes and effects. For instance, the health crisis triggered by the COVID-19 pandemic had severe global economic consequences [83], while the 2008 financial crisis led to significant social challenges [84]. Military threats can also contribute to crises, as demonstrated by the influx of immigrants to Europe [7]. As shown in Table 1, the early 21st century has been marked by a variety of global crises with diverse origins. This suggests that a range of threats will likely continue to arise in the future, highlighting the need to explore sustainable transport solutions that could prove effective in mitigating potential global crises.

2.3. Assumptions of Sustainable Transport Development

In analyzing the literature on transport solutions, it is essential to consider the concept of sustainable transport development and its key principles. According to the Organization for Economic Co-operation and Development (OECD), sustainable transport is one that does not endanger public health and meets the needs for access consistent with the use of renewable resources below their rates of generation, and use of non-renewable resources below the rates of development of renewable substitutes [85]. The Centre for Sustainable Transportation (CST) provides a more detailed explanation. It states that a sustainable transportation system is one that:

- Allows the basic access and development needs of individuals and societies to be met safely, and with equity within and across generations (social dimension).
- Is affordable, operates fairly and efficiently, and fosters sustainable regional development (economic dimension).
- Limits emissions and waste and minimizes the use of land and production of noise.

- Functions based on a participatory process that includes relevant stakeholders from all parts of society (degree of participation) [86,87].

Dalkmann and Huizenga [88] further emphasized that sustainable transport should limit both short- and long-term negative impacts on local and global environments, feature economically viable infrastructure and operations, and provide safe and secure access for people and goods. Achieving the objectives outlined in these definitions necessitates specific actions focused on developing sustainable transport, which can be categorized into four main areas (Figure 2).

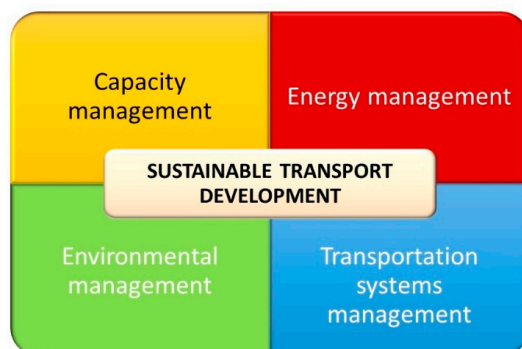


Figure 2. Main areas of action for sustainable transport development.

The principles of sustainable transport development can primarily be implemented through effective management of transport systems. This includes optimizing transport needs and improving the flow of passengers and goods [89,90]. Another key focus is capacity management, which aims to reduce society's reliance on passenger cars. This can be achieved by promoting alternatives, such as public transport, cycling, and walking [91]. Minimizing environmental impacts is also crucial for sustainable transport development, primarily by reducing exhaust emissions, noise, and waste (e.g., oils and batteries) [92,93]. Furthermore, as shown in Figure 2, sustainable transport development can be facilitated by decreasing dependence on fossil fuels (energy management) through the use of electric vehicles, biofuels, or other alternative fuels [94,95].

In this article, transport solutions are analyzed in accordance with the definitions, principles, and areas of action presented in this section. These solutions not only align with the concept of sustainable development but also enhance the level of safety and stability in the transport sector during crisis events.

3. Materials and Methods

In this paper, a systematic literature review was conducted to identify the latest advances in sustainable transport development and to highlight their significance in the context of potential global crises. Four different databases were used for this purpose: Scopus, Google Scholar, DOAJ, and IEEE. The review was conducted between August and October 2024. The systematic review method employed in this publication is based on the approach outlined by Liberati et al. [96], which aligns with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [97]. This methodology is also commonly used in studies by other researchers [54,98–100].

The latest advances in the area of sustainable transport development were classified according to the breakdown detailed in Section 2.1. Global crises were categorized based on Borca et al. [54], Gundel [55], and Sawada [56]. Additionally, military crises were included due to recent geopolitical tensions in various regions around the world [57,58] (Section 2.2). The concept of 'sustainable transport' was clarified with a specific definition provided for this study (Section 2.3). The database search focused on metadata, including titles, abstracts, and keywords. It is important to note that the specific databases differ in

their filtering capabilities. Table 3 presents the metadata searched in each database, along with the search records.

Table 3. Metadata searched in selected databases.

Database	Searched Metadata	Entered Search Records
Scopus	Title, abstract, keywords	TITLE-ABS-KEY: (global OR economic OR environmental OR climate OR health OR social OR migration OR military OR pandemic) AND (crisis OR threats) AND (sustainable) AND (transport OR transportation) AND (development OR solution OR advances OR innovation)
Google Scholar	Title, keywords	((intitle: global OR keyword: global) OR (intitle: economic OR keyword: economic) OR (intitle: environmental OR keyword: environmental) OR (intitle: climate OR keyword: climate) OR (intitle: health OR keyword: health) OR (intitle: social OR keyword: social) OR (intitle: migration OR keyword: migration) OR (intitle: military OR keyword: military) OR (intitle: pandemic OR keyword: pandemic)) AND ((intitle: crisis OR keyword: crisis) OR (intitle: threats OR keyword: threats)) AND (intitle: sustainable OR keyword: sustainable) AND ((intitle: transport OR keyword: transport) OR (intitle: transportation OR keyword: transportation)) AND ((intitle: development OR keyword: development) OR (intitle: solution OR keyword: solution) OR (intitle: advances OR keyword: advances) OR (intitle: innovation OR keyword: innvation))
DOAJ	Title, abstract, keywords	((TI: global OR ABS: global OR KEY: global) OR (TI: economic OR ABS: economic OR KEY: economic) OR (TI: environmental OR ABS: environmental OR KEY: environmental) OR (TI: climate OR ABS: climate OR KEY: climate) OR (TI: health OR ABS: health OR KEY: health) OR (TI: social OR ABS: social OR KEY: social) OR (TI: migration OR ABS: migration OR KEY: migration) OR (TI: military OR ABS: military OR KEY: military) OR (TI: pandemic OR ABS: pandemic OR KEY: pandemic)) AND ((TI: crisis OR ABS: crisis OR KEY: crisis) OR (TI: threats OR ABS: threats OR KEY: threats)) AND (TI: sustainable OR ABS: sustainable OR KEY: sustainable) AND ((TI: transport OR ABS: transport OR KEY: transport) OR (TI: transportation OR ABS: transportation OR KEY: transportation)) AND ((TI: development OR ABS: development OR KEY: development) OR (TI: solution OR ABS: solution OR KEY: solution) OR (TI: advances OR ABS: advances OR KEY: advances) OR (TI: innovation OR ABS: innvation OR KEY: innovation))
IEEE	Title, abstract, keywords	("All Metadata": global OR economic OR environmental OR climate OR health OR social OR migration OR military OR pandemic) AND ("All Metadata": crisis OR threats) AND ("All Metadata": sustainable) AND ("All Metadata": transport OR transportation) AND ("All Metadata": development OR solution OR advances OR innovation)

A search of selected databases identified 484 items. Table 4 lists the number of results obtained from each database. In addition, 8 studies from supplementary sources—other databases and results obtained directly through web searches—were included. These publications were considered important, as they deal with transport solutions that can be crucial to enhancing security during environmental, health, and military crises.

Table 4. Number of studies obtained from each database.

Database	Scopus	Google Scholar	DOAJ	IEEE	Other Sources	Sum
Number of studies	161	143	57	123	8	492

The extracted entries were then checked for duplicate searches. A total of 49 duplicate publications were identified and removed from the collection, resulting in 443 studies remaining. Furthermore, additional inclusion and exclusion criteria were applied to the literature review, which were considered when analyzing titles and abstracts (Table 5).

Table 5. Inclusion and exclusion criteria for publications in this literature review.

Inclusion Criteria	Justification
Publication in a peer-reviewed journal	Articles from peer-reviewed journals reflect the current state of knowledge of the scientific community in a given research area
The article describes the latest solutions for the development of sustainable transport	The aim of the study is to identify the latest solutions in the development of sustainable transport and indicate their importance in the event of global crises
Paper presents the possibilities of using modern technologies in transport in the event of crises	
Exclusion criteria	Justification
No full text available	An article is only relevant to the review if the full text is available
The article is not written in English	English is a commonly used language in the scientific community and is, therefore, understandable to the authors
Studies were published before 2020	The study presents recent solutions in transport

After applying the defined inclusion and exclusion criteria, 157 entries were excluded from the review. As a result, 286 studies were extracted as a body of literature for further analysis. In the next stage, another 63 publications were eliminated due to a lack of thematic relevance to the review. Ultimately, 223 studies were gathered for further use in descriptive and thematic analysis. The purpose of the descriptive categories was to extract data from the literature useful for describing and differentiating studies. The thematic categories were used to identify and classify the solutions examined in this publication. Based on the current state of knowledge, seven categories of solutions in the area of sustainable transport development were listed, particularly significant in the context of global threats. This classification structured Section 4.2. The descriptive and thematic categories included in the review are presented in Table 6.

Table 6. Descriptive and thematic categories used to extract data from the literature.

Category Group	Category	Information Obtained
Descriptive (description and differentiation of studies)	Publication date	Year of publication
	Journal	Name of the journal
	Author	Names and surnames of authors
	Title	Full title of the paper
Thematic (classification of solutions)	Technologies in vehicle drives	Information on solutions in the area of sustainable transport development that can increase the stability of the economy and the resilience of the transport sector to potential global crises
	Intelligent transport systems (ITS)	
	Innovations in logistics and supplies	
	Integration and management of transport systems	
	Development of transport infrastructure	
	Modern solutions in vehicles	
	Advances in public transport	

The procedure for selecting publications for the review is illustrated in a flowchart in Figure 3. As mentioned earlier, this procedure follows the PRISMA approach [97], utilized by authors such as Liberati et al. [96] and Borca et al. [54].

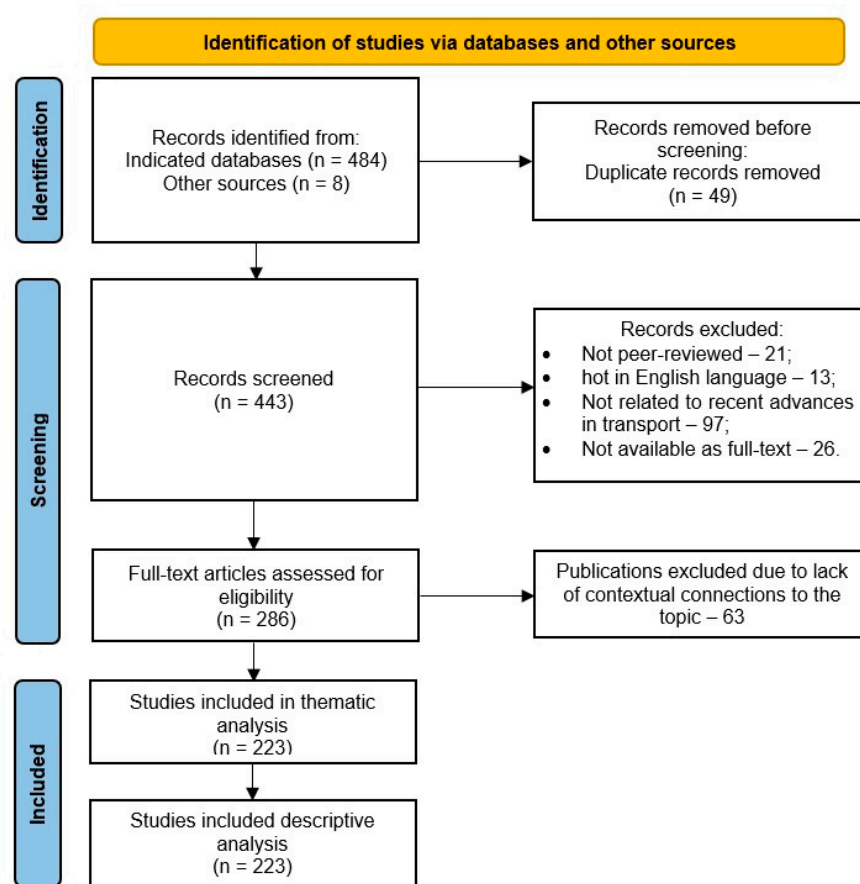


Figure 3. Flowchart for the selection of publications for the literature review.

Ultimately, based on the procedure outlined in this section, 223 scientific publications describing the latest advances in sustainable transport development, particularly relevant in light of global crisis threats, were singled out. The results from this literature review will be presented in the next section of the article (Section 4).

4. Results from the Literature Review

4.1. Recent Advances for the Development of Sustainable Transport

Based on a review of the literature, 223 publications were selected as relevant to the study. Each transport solution was categorized, and relevant literature sources used in the detailed analysis were noted. The findings are summarized in Table 7.

Table 7. Recent transport solutions found as a result of the literature review.

Category	Solution	References
Technologies in vehicle drives	Battery electric vehicles (BEV)	[29,101–111]
	Fuel cell electric vehicles (FCEV)	
	Plug-in hybrid electric vehicles (PHEV)	
	Biofuel-powered vehicles	[112–115]
	Solar-powered vehicles	[116–119]
	Compressed air vehicles	[120–123]
Intelligent transport systems (ITS)	Autonomous vehicles (AV)	[124–131]
	Traffic management systems (TMS)	[31,132–137]
	Emissions' monitoring and control systems	[138–143]
	Real-time mobility management systems	[144–147]
	Smart lighting systems	[148–152]
Innovations in logistics and supplies	Drone-based logistics	[23,153–161]

Integration and management of transport systems	Autonomous trucks	[36,162–166]
	The use of blockchain	[167–173]
	Last-mile logistics solutions	[35,174–179]
	MaaS (Mobility as a Service)	[37,180–187]
	Intelligent fleet management systems	[188–197]
Development of transport infrastructure	Real-time public transport management	[38,39,198–202]
	Smart parking systems (SPS)	[40,203–211]
	Infrastructure for electric vehicles	[212–219]
	Smart roads	[24,41,220–225]
Modern solutions in vehicles	Green infrastructure in transport	[226–235]
	Connected car	[43,236–245]
	Vehicle-to-Everything (V2X)	[188,246–256]
	Advanced driver assistance systems (ADAS)	[44,257–265]
	Modular vehicles	[266–277]
Advances in public transport	Autonomous buses	[45,278–284]
	On-demand public transport	[46,47,146,285–288]
	In-vehicle air quality monitoring systems	[289–296]
	Contactless payment systems	[293,297–302]
	Smart stops and stations	[48,49,303–305]

As shown in Table 7, there are numerous examples of modern transport solutions that align with sustainable development goals while also strengthening economic resilience—particularly within the transport sector—in preparation for potential global crises. The majority of innovations were concentrated in modern vehicle technologies and in the integration and management of transport systems, with 81 out of the 223 papers focusing on these areas. A substantial number of publications also addressed advancements in public transport (35 out of 223 papers) and intelligent transport systems (30 out of 223 papers). Notably, many transport solutions span across categories, reflecting cohesive development efforts within the field. The selected studies provided a basis for a detailed description of the solutions and an analysis of their potential application in crisis scenarios. The findings are discussed in the following section.

4.2. Importance of Recent Solutions in Transport in Case of Global Crises

4.2.1. Technologies in Vehicle Drives

The literature review identified six vehicle drive technologies that align with sustainable development principles and could play a critical role in safeguarding the economy, including the transport sector, during global crises (Table 8).

BEV, FCEV, and PHEV

Electric drive technologies continue to advance, resulting in several types of vehicles that use electric energy. Battery electric vehicles (BEVs) are fully electric and powered by a battery that is charged from an external source. BEVs eliminate local emissions, significantly reducing CO₂ emissions and improving air quality in urban areas [101]. Fuel cell electric vehicles (FCEVs), similar to BEVs, use electric motors; however, the energy is produced by a reaction between hydrogen and oxygen in a fuel cell, with water being the only byproduct, making FCEVs completely emission-free [102]. Plug-in hybrid electric vehicles (PHEVs) combine the advantages of both electric and combustion engines. The electric motor supplements the combustion engine, and the battery can be charged from external sources (charging stations). PHEVs can run on electric power for short distances, reducing CO₂ emissions, while offering the range of traditional vehicles for long-distance travel [103].

Research on electric drive technologies has primarily focused on extending vehicle range [29,104], increasing battery charging speeds [105], and reducing production costs [106]. Progress in these areas is vital for promoting electric mobility, which can help meet

growing transport demands while reducing emissions from the sector [107]. Electric-powered vehicles (BEVs, FCEVs, and PHEVs) not only align with sustainable transport goals but could also be particularly useful in global crises. By relying on electricity as a power source, they reduce the consumption of fossil fuels, supporting long-term preservation of natural resources [108]. In addition, the use of renewable electricity or locally sourced hydrogen can lessen dependency on imports, ensuring transport even when access to traditional fuels is disrupted [109]. Electric vehicles also contribute to the development of more accessible transport systems, which is essential for maintaining mobility in crisis situations [107,110]. Their quiet operation is an additional advantage, especially in military operations that require discretion [111].

Biofuel-Powered Vehicles

Due to the depletion of fossil fuels, undesirable changes in climatic conditions, and increased air pollution, research is being conducted into alternative and sustainable ways to meet energy needs. One such solution is biofuels produced from biomass, which include bioethanol, biodiesel, and biogas. Currently, the fourth generation of biofuels is being developed, involving innovative production methods, such as genetic engineering and nanotechnology, aimed at improving efficiency and reducing production costs [112].

The use of biofuels may be of particular importance in the face of potential crises. Biofuels offer an alternative to fossil fuels, reducing the economy's dependence on oil and thereby lowering the risk of fuel supply disruptions during crises [113]. In addition, biofuel vehicles can reduce greenhouse gas emissions, mitigating the negative impact of transport on climate change and air quality, which in turn supports public health improvements [114]. There are also studies confirming that biofuels can provide an alternative and effective power source for military combat vehicles [115].

Solar-Powered Vehicles

Solar-powered vehicles show great potential as a clean, renewable, and environmentally friendly means of transport. They operate by using photovoltaic panels to generate electricity that powers the vehicle. Research on this technology focuses primarily on extending their range by improving the efficiency of photovoltaic cells and optimizing sunlight exposure while driving [116]. Hybrid systems are also being developed, where solar energy from the panels supplements the battery power of EVs [117]. Solar-powered vehicles produce no harmful emissions, contributing to improved air quality and reducing the environmental impact of transport. Additionally, harnessing renewable solar energy lowers both fossil fuel consumption and reliance on these non-renewable resources [118]. Another key benefit is that solar energy is accessible even in remote, underdeveloped areas, offering a relatively affordable transport solution [119].

Compressed Air Vehicles

A promising technology for achieving zero emissions is the use of compressed air drive systems. Vehicles powered by this method operate by converting the internal energy of compressed air into mechanical energy [120] and can be powered either solely by compressed air or in combination with other fuels, such as gasoline or diesel [121]. Unlike traditional power systems, compressed air does not contribute to environmental degradation or emit harmful compounds into the atmosphere. Additionally, compared to fully electric and hydrogen-powered vehicles, compressed air systems do not generate the pollution associated with battery production and fuel cell disposal, making them a more environmentally friendly option throughout their entire lifecycle [122]. Research also indicates that using compressed air as a supplementary power source can significantly reduce conventional fuel consumption, leading to lower transport costs [123].

Table 8. The role of selected solutions in technologies in vehicle drives during potential global crises.

Solution	Role in Case of Potential Crises
Battery electric vehicles (BEV)	• Savings in fossil fuel consumption (economic crisis and environmental crisis) • Reducing pollutant emissions and improving air quality (environmental crisis and health crisis)
Fuel cell electric vehicles (FCEV)	• Less dependence on fuel imports when using renewable electricity or local hydrogen sources (economic crisis and military crisis) • Useful in military operations where silence and discretion are required (military crisis)
Plug-in hybrid electric vehicles (PHEV)	• Possibility to carry out transport even when access to traditional fuels is limited due to war operations (military crisis) • Support for the development of more accessible transport systems for society (economic crisis and social crisis)
Biofuel-powered vehicles	• Reduced dependence on oil—less risk of fuel supply interruptions (economic crisis and military crisis) • Reducing emissions and improving air quality (environmental crisis and health crisis) • Possibility of using biofuels in military vehicles (military crisis)
Solar-powered vehicles	• Reducing pollutant emissions and improving air quality (environmental crisis and health crisis) • Lower transportation costs and energy availability for poor regions (social crisis)
Compressed air vehicles	• Lower transportation costs (economic crisis and social crisis) • No lifecycle emissions and improvement of air quality (environmental crisis and health crisis)

4.2.2. Intelligent Transport Systems (ITS)

Through an analysis of recent research advancements, five examples of transport solutions were identified within the intelligent transport systems (ITS) category. These solutions align with sustainable transport principles and hold significant potential for mitigating global crises (Table 9).

Autonomous Vehicles (AV)

Advances in technology are transforming traditional transport into fully functional, intelligent machines. These vehicles, equipped with sophisticated systems, can sense their surroundings, connect to networks, make decisions, and travel independently, while ensuring pedestrian and passenger safety. Autonomous vehicles (AVs) represent the current pinnacle of intelligent transport development [124]. Studies indicate that widespread adoption of AVs, particularly electric autonomous vehicles (AEVs), could play a substantial role in sustainable development by reducing greenhouse gas emissions by up to 34% of total transport emissions by 2050 [125]. Moreover, AVs have the potential to improve urban air quality by lowering NO_x and CO₂ levels, which is essential for maintaining public health [126]. Research also suggests that AVs integrated with IoT technology could enhance customer service and reduce logistics costs, aiding businesses in navigating economic crises [127]. Additionally, autonomous vehicles offer advantages in times of pandemic by enabling contactless delivery of essential goods, such as medicine and medical equipment [128,129]. In the context of armed conflicts, they could be valuable for evacuating injured individuals from conflict zones [130] or even serving as combat vehicles [131].

Traffic Management Systems (TMS)

Intelligent traffic management systems offer a solution to urban traffic congestion by relying on advanced technological infrastructure, which leverages innovations, such as the Internet of Things (IoT), vehicular ad hoc networks (VANET), cloud computing, 5G connectivity, and Big Data. These systems support traditional traffic management methods while effectively reducing congestion [132]. Reducing traffic jams leads to decreased fuel consumption, shorter travel times, and improved road safety, all of which positively impact the economy [133]. Some proposals suggest expanding these systems to include UAV traffic monitoring, which could reduce the risk of collisions and accidents, thereby benefiting public health and offering cost savings [134]. Studies also highlight the utility

of TMS during health crises, such as pandemics, as they can facilitate social distancing by managing traffic flow and optimizing transport resources [135], even prioritizing emergency vehicles, such as ambulances [31]. Additionally, intelligent traffic management aligns with sustainable transport goals by reducing vehicle idle time, thereby lowering fuel consumption and greenhouse gas emissions [136]. TMS also become valuable in crises that require rapid urban evacuation, such as armed conflicts or social unrest [137].

Emissions' Monitoring and Control Systems

Transport has a significant environmental impact, producing noise and pollutant emissions that degrade air quality and contribute to climate change. Modern technologies provide opportunities to sustainably develop this sector, helping to reduce its adverse effects on the climate. Intelligent emissions' monitoring and control systems offer a solution for tracking, analyzing, and managing transport-related pollution. These systems use integrated technologies, including advanced sensors, artificial intelligence (AI), and the Internet of Things (IoT), to enable real-time data collection and analysis. Besides monitoring emissions, such as carbon dioxide, nitrogen oxides, and particulate matter from vehicle exhaust, these systems assess air quality and noise levels [138]. Continuous monitoring and real-time reporting facilitate swift interventions to curb greenhouse gas emissions [139,140], which is crucial for mitigating global warming and addressing the environmental crisis. Emissions' monitoring and control systems are also vital in health crises, where air quality is critical for public health [141]. During the COVID-19 pandemic, these systems were widely implemented, helping to reduce pollution levels and potentially influencing disease outcomes [142,143].

Real-Time Mobility Management Systems

Addressing urban challenges with AI-based traffic management solutions, cities are exploring real-time traffic management systems to optimize routing and ease congestion. These systems are supported by applications that allow users to select from various transportation modes and routes on a single platform (known as mobility on demand). This innovative traffic management approach aims to reduce congestion, enhance travel time reliability for commuters, and improve the economic efficiency of transport systems, which is particularly valuable during sudden economic disruptions [144]. In addition, AI-supported management, coupled with Internet of Things (IoT) capabilities, enables real-time route planning and reduces fuel consumption through congestion relief—making it an approach aligned not only with sustainable transport goals but also with environmental crisis management [145]. Studies suggest this innovative approach could also play a role in health crises, such as pandemics, by supporting social distancing and optimizing transport demand [146]. Moreover, this solution could support the coordination of ambulance traffic, providing significant public health benefits [147].

Smart Lighting Systems

Proper lighting is essential for visibility, which greatly enhances travel comfort and road safety. However, streetlight operation requires substantial energy, incurring significant costs and environmental impacts. Consequently, extensive research is directed toward improving the efficiency of lighting systems [148]. Advances in both wired and wireless networks, control technologies, and embedded systems now allow for modern lighting solutions that minimize energy consumption. Smart lighting systems, which can automatically adjust light intensity in real time based on current needs (e.g., traffic volume, time of day, and weather conditions), are increasingly regarded as key tools for reducing energy waste and, in a broader perspective, for limiting greenhouse gas emissions [149]. Moreover, IoT-enabled smart lighting systems, supported by advanced control units, can lower electricity costs—a particularly valuable benefit when financial resources are constrained [150,151]. Research also highlights that these systems allow for optimal lighting of critical zones, such as bus stops, transit stations, and pedestrian crossings, facilitating

crowd management, reducing accident risk, and enhancing overall urban safety, especially at night [152].

Table 9. The role of selected solutions in intelligent transport systems (ITS) during potential global crises.

Solution	Role in Case of Potential Crises
Autonomous vehicles	- Reducing greenhouse gas emissions and the potential for air quality improvement (environmental crisis) - Increased customer service level and reduced logistics costs in enterprises (economic crisis) - Possibility of contactless delivery of goods, including medicines and medical equipment (health crisis) - Use for evacuation of the wounded or as combat vehicles (military crisis)
Traffic management systems	- Reduction of transport congestion—decrease in fuel consumption, shorter travel times, and reduction of exhaust emissions (economic crisis and environmental crisis) - Reducing the risk of collisions and accidents (economic crisis and health crisis) - Social distancing support (health crisis) - Possibility of giving passage priority to emergency vehicles (health crisis and social crisis) - Improving the evacuation of the population from cities (military crisis and social crisis)
Emission monitoring and control systems	- Reducing greenhouse gas emissions and improving air quality (environmental crisis and health crisis) - Possibility of taking immediate action to reduce excessive exhaust emissions and improve the condition of the atmosphere (environmental crisis and health crisis)
Real-time mobility management systems	- Reducing congestion and improving the economic efficiency of the entire transport system (economic crisis) - Reducing fossil fuel consumption and carbon dioxide emissions (environmental crisis) - Application in the maintenance of social distancing and the planning of transportation demand (health crisis) - Support for the coordination of ambulance traffic (social crisis and health crisis)
Smart lighting systems	- Reducing electricity consumption—decreasing greenhouse gas emissions and lower expenses for energy (environmental crisis and economic crisis) - Increasing the level of safety with proper lighting (economic crisis, social crisis, and health crisis)

4.2.3. Innovations in Logistics and Supplies

Recent advancements in logistics and supply chains align with principles of sustainable transport and hold potential as critical responses to global crises. A literature review identified four notable examples of such innovations (Table 10).

Drone-Based Logistics

Drones, or unmanned aerial vehicles (UAVs), are compact aircraft that can be equipped with various devices, including cameras, thermal sensors, GPS, communication systems, and specialized tools. These devices support tasks such as environmental monitoring, technical inspections, parcel delivery, and emergency response operations. The primary advantage of drones is their ability to access and navigate challenging and remote areas with ease [23], positioning them as promising assets for logistics and delivery solutions that promote sustainable development and provide valuable support during global crises. For businesses and governments, drones offer an innovative method to enhance logistics efficiency, enabling automated deliveries, reducing transport times, and lowering fuel consumption, which collectively reduce operational costs [153,154]. Studies indicate that, in comparison to traditional vehicles, electric UAVs can significantly cut greenhouse gas emissions, contributing positively to environmental sustainability [155]. Drones have also proven valuable during health crises, as evidenced during the COVID-19 pandemic, where they enabled efficient, contactless delivery of medications, SARS-CoV-2 tests, personal protective equipment, and even vaccines [156–158]. The literature further highlights UAV-based logistics as a vital resource in humanitarian aid during natural disasters, social conflicts, and even armed conflicts. In such scenarios, drones effectively support

emergency medical systems [159] and the transportation of essential resources, such as medications, food, and water [160,161].

Autonomous Trucks

Autonomous trucks are equipped with technology that enables driverless cargo transport. Using advanced systems, such as artificial intelligence (AI), sensors, cameras, LIDAR data, and GPS, these vehicles can independently navigate roads, plan routes, and make safety-related decisions [36,162]. Progress in autonomous truck technology can substantially improve the efficiency of logistics and supply chains while reducing the environmental impact, aligning with sustainable transport objectives. When paired with electric or hybrid engines, autonomous trucks can also cut CO₂ emissions, supporting climate action efforts and improving air quality [163]. Autonomous trucks provide the benefit of real-time control over driving parameters and rapid responsiveness to changing road conditions, resulting in lower fuel consumption, resource conservation, and cost savings for transport companies. Without the need for drivers, these vehicles can operate continuously, reducing transport times and enhancing supply chain efficiency [164]. Research into autonomous convoys also underscores their potential in military or humanitarian crisis settings. Fully autonomous convoys can deliver essential supplies to areas where traditional transport is unsafe or inaccessible, thereby increasing logistics safety in high-risk areas and minimizing human exposure to risk [165,166].

The Use of Blockchain

Blockchain technology enables decentralized data storage and transfer without intermediaries or a central system. As a digital ledger, blockchain is made up of interconnected blocks that record transactional information, with each block containing data from the previous one, forming a secure chain [167]. In logistics and transport, blockchain allows for fast, transparent tracking of goods flow, reducing risks of fraud, counterfeiting, and administrative errors. Its transparency, traceability, and reliability allow companies to manage resources effectively, reduce costs, and maintain stability in times of economic uncertainty [168]. This technology has also demonstrated its value in health crises, such as during the COVID-19 pandemic, by enabling secure tracking of medical supply chains, equipment, and patient records [169]. Blockchain further supports eco-friendly practices in supply chains by enabling tracking of location and pollution data (primarily CO₂), which enhances transparency in corporate sustainability efforts [170]. Blockchain's role in humanitarian aid is also significant, providing precise tracking of deliveries to at-risk areas and ensuring resources are fairly distributed to those in need [171,172]. In military logistics, blockchain can offer secure, transparent tracking of supplies and equipment, reducing the risks of errors, delays, and other logistical challenges that could affect mission success [173].

Last-Mile Logistics Solutions

Last-mile logistics represents the final step in delivering goods from a warehouse or distribution center to the end consumer. This area faces numerous challenges today, including growing volumes of goods, time constraints, rising costs, an aging workforce, and sustainability concerns [174]. Emerging solutions include autonomous vehicles, alternative transport methods, and distributed warehousing systems. Technologies such as UAVs and small unmanned ground vehicles (SUGVs) reduce delivery costs through automation, route optimization, and lower expenses for wages, fuel, and vehicle maintenance, supporting the financial stability of businesses [35]. The use of UAVs, light electric freight vehicles (LEFV), and alternative transport modes, such as electric cargo bikes or tricycles, also helps alleviate urban congestion and reduce carbon emissions, advancing sustainable development goals. Compared to traditional delivery vehicles, these options require less road space and offer greater ease of access and parking [175,176]. Studies further underscore the importance of last-mile logistics innovations for public health. Solutions such as delivery networks of cooperating unmanned ground vehicles (UGVs) [177] or the

transport of medicines, food, and healthcare supplies by drones or autonomous robots have proven invaluable during public health crises. During the COVID-19 pandemic, these technologies enabled safe, rapid, and contactless delivery of essential goods, reducing infection risks and maintaining supply chain continuity despite movement restrictions [178,179].

Table 10. The role of selected innovations in logistics and supplies during potential global crises.

Solution		Role in Case of Potential Crises
Drone-based logistics	•	Increased efficiency of logistics, thanks to automated deliveries and shortened transport times (economic crisis)
	•	Reducing the use of conventional fuels and greenhouse gas emissions (environmental crisis and health crisis)
	•	Possibility of quick and contactless delivery of medicines, personal protective equipment, and vaccines (health crisis)
	•	Support of emergency medical systems and efficient transport of essential resources—medicine, food, and water (social crisis and military crisis)
Autonomous trucks	•	Reducing carbon dioxide emissions and improving air quality (environmental crisis and health crisis)
	•	Increasing the efficiency of supply chains and reducing operating costs thanks to the ability to quickly respond to prevailing road conditions, reducing fuel consumption and eliminating the employment of drivers (economic crisis)
	•	Use of autonomous convoys to safely deliver resources to dangerous areas (social crisis and military crisis)
The use of blockchain	•	Ensuring transparency, traceability, and reliability of the entire supply chain—effective resource management (economic crisis)
	•	Monitoring the transport of medical supplies and devices, as well as patient records (health crisis)
	•	Tracking the location and level of pollutant emissions in supply chains and ensuring transparency regarding the sustainable activities of companies (environmental crisis and health crisis)
	•	Monitoring supplies to threatened areas and supervising the distribution of resources (social crisis and military crisis)
	•	Reducing the risk of errors, delays, and other logistical challenges that may significantly affect the success of an operation (military crisis)
Last-mile logistics solutions	•	Reducing delivery costs through automation, route optimization, as well as reducing expenditure on salaries, fuel, and vehicle operation (economic crisis)
	•	Reducing urban congestion and minimizing carbon dioxide emissions (environmental crisis and health crisis)
	•	Ensuring continuity of supply during mobility restrictions and the safe and contactless delivery of essential goods (health crisis)

4.2.4. Integration and Management of Transport Systems

The literature review highlighted four solutions that advance sustainable transport development and can play a crucial role in global crises (Table 11).

Mobility as a Service (MaaS)

Mobility as a Service (MaaS) is an innovative concept that greatly enhances transport integration by offering a unified solution to the diverse range of transport options available. MaaS is an integrated platform that combines public, private, and shared transport modes, allowing users to not only find the best travel option for their needs but also to pay for their entire journey as a single, seamless service. The decision-making process is simplified and managed conveniently through a single mobile application [180].

MaaS is consistently evolving to provide safe and sustainable mobility solutions to the population, which in turn promotes its widespread adoption and social acceptance. One of the key directions of development is the inclusion of the Sustainable Development Goals (SDGs), which allows transforming this platform into an even more environmentally friendly one, i.e., sustainable MaaS (S-MaaS) [181]. Research shows that integrating multiple transport modes, particularly electric and shared mobility options (e.g., car sharing and bike sharing), can significantly lower carbon dioxide emissions and reduce air pollution. This is especially relevant in addressing environmental crises, such as global warming, as it mitigates transport's impact on the climate and promotes eco-

friendly travel options [182,183]. MaaS also offers economic resilience by reducing transport costs. For consumers, it minimizes personal vehicle expenses and provides cost-effective alternatives for daily travel. For companies, the rising demand for shared services, such as car sharing, urban bike rentals, and integrated public transport, helps reduce fleet maintenance costs by spreading expenses across multiple users [184–186]. Research also suggests that Mobility as a Service can be effective in health crises, as seen during the COVID-19 pandemic. Key benefits include reduced interpersonal contact and the ability to maintain social distancing by using rented, individual transport options. Booking and contactless payment options further enhance safety for users [37,187].

Intelligent Fleet Management Systems

Companies that operate vehicle fleets—such as trucks, delivery vehicles, taxis, and buses—must prioritize efficient use and management of their transport assets to maintain competitiveness. Intelligent fleet management systems provide critical support by employing advanced technologies, such as IoT, cloud computing, and Big Data, to optimize vehicle operations, track usage, and enable real-time decision-making [188,189]. These systems enhance transport service control by ensuring adherence to routes and schedules and monitoring traffic violations, thereby improving both passenger service quality and road safety. Additionally, they monitor driver speed and driving behavior, contributing to lower fuel consumption and reduced operational costs [190–192]. During health crises, intelligent fleet management systems are invaluable for tracking vehicle movement and monitoring drivers' compliance with sanitation protocols, ensuring safe and timely transport of essential goods, such as medicines and medical supplies. The system also allows for route optimization and real-time vehicle updates, taking into account obstacles and traffic density [193,194], which helps minimize interpersonal contact—a critical factor in pandemics. Furthermore, these systems can be adapted to manage emergency vehicles, offering benefits such as route planning, access to patient information, accident detection, driver distraction recognition, and additional support tools [195]. In environmental crises, intelligent fleet management reduces emissions through route optimization and fuel-saving measures [190]. When integrated with electric vehicle fleets, these systems are particularly eco-friendly, especially when optimal energy management and advanced charging strategies are used [196,197].

Real-Time Public Transport Management

The development and deployment of intelligent, real-time public transport management systems are rapidly advancing in urban areas, particularly those with complex transport networks. These systems utilize a suite of interconnected technologies, including the Internet of Things (IoT), Big Data, artificial intelligence (AI), cloud computing, and edge computing. This integration provides real-time insights into public transport operations by enabling data collection, integration, and processing across intelligent traffic infrastructures and VANET [38,198]. Research highlights the benefits of such systems, particularly for bus transport, where optimized route selection and scheduling can lower operational costs, reduce travel times for passengers, generate economic benefits for operators, cut CO₂ emissions, and promote environmental sustainability [199]. Buses serve as a vital component of sustainable urban mobility; however, their travel times are significantly affected by street congestion [39]. Real-time passenger information systems address this challenge by providing travelers with updated arrival times, potential delays, and schedule modifications, enabling more efficient journey planning and reducing wait times at stops [200]. Another benefit of real-time public transport management lies in its adaptability to passenger demand, allowing for dynamic schedule adjustments that minimize overcrowding and support social distancing—a feature particularly valuable during health crises, such as the COVID-19 pandemic [201,202].

Smart Parking Systems (SPS)

Traditional parking practices often lead to inefficiencies, including congestion caused by drivers searching for available spaces and challenges in revenue management for operators. Smart parking systems (SPS) address these issues by providing real-time information on parking spaces' availability, optimizing space utilization, and offering streamlined payment options. SPS comprises multiple interconnected technological components that collectively enhance car park management and user satisfaction. Key elements include occupancy sensors in parking spaces, a data communication network, a data management system for processing and analysis, and a user application [40,203]. Smart parking systems reduce parking-related costs for cities and drivers alike by automating and optimizing parking processes, thus promoting better space utilization, decreased vehicle traffic, and lower management expenses. The ability for users to reserve spaces, navigate to locations, and pay via an app saves time and fuel [204,205]. These systems also hold environmental relevance by mitigating congestion [206] and reducing the time required to find a parking space, thereby lowering greenhouse gas emissions from vehicle exhaust [207]. Studies also indicate that integrating smart parking systems with the electric vehicle (EV) charging infrastructure increases the availability of charging stations, improves user convenience, and supports sustainable transport development [208,209]. SPS can also play a critical role in health crises by minimizing human interaction through cashless payments and remote reservations [210]. Furthermore, smart parking areas can be repurposed as distribution centers for vaccines, facilitating efficient vaccination processes [211].

Table 11. The role of selected solutions in the integration and management of transport systems during potential global crises.

Solution	Role in Case of Potential Crises
Mobility as a Service (MaaS)	- Reducing carbon dioxide emissions and air pollution (environmental crisis and health crisis) - Lower transport costs for users and reduction of expenditure on the provision of transport services by enterprises (economic crisis) - Possibility to limit interpersonal contacts and maintain social distancing by renting individual means of transport, as well as the option to book a ride and make contactless payments (health crisis)
Intelligent fleet management systems	- Possibility to control the implementation of transport services in terms of route and schedule compliance, monitor traffic violations, and supervise the way the vehicle is driven (economic crisis) - Monitoring vehicle traffic and checking drivers' compliance with sanitary rules and optimizing routes in terms of traffic disruptions and intensity (health crisis) - Possibility of using it to manage emergency vehicles (health crisis, social crisis, and military crisis) - Reducing exhaust emissions and improving air quality (environmental crisis and health crisis)
Real-time public transport management	- Reduction of costs and travel times for passengers and lower expenditure on transport by enterprises (economic crisis) - Reducing carbon dioxide emissions and environmental pollution (health crisis and environmental crisis) - Ability to respond quickly to the current occupancy of running vehicles—minimizing congestion and maintaining social distancing (health crisis)
Smart parking systems	- Reduction of costs and time associated with vehicle parking (economic crisis) - Reducing greenhouse gas emissions and improving air quality in cities (environmental crisis and health crisis) - Reducing human interaction through cashless payments and remote parking reservations (health crisis) - Possibility of using parking lots as vaccine distribution centers (health crisis)

4.2.5. Development of Transport Infrastructure

Infrastructure plays a foundational role in any transport system, supporting both existing and future solutions. A review of the literature identified three primary research areas in transport infrastructure, with a focus on sustainable development and adaptability during global crises (see Table 12).

Infrastructure for Electric Vehicles

The electrification of transport is a prominent focus in recent studies. Electric vehicles (EVs) are increasingly accepted by the public, steadily growing their market share. Key factors influencing EV popularity include driving range, as well as the convenience and cost of energy supply—both of which largely depend on the availability and strategic placement of charging infrastructure [212]. Research underscores the importance of government financial support for initiatives such as fast-charging stations, which are essential to the wider adoption of EVs, fostering economic growth and promoting sustainability [213]. Expanding EV infrastructure, particularly through an accessible charging network, has a direct impact on consumer purchasing decisions and supports EV adoption [214]. The resulting rise in EVs on the roads, facilitated by adequate charging access, can significantly reduce exhaust emissions, contributing to improved air quality [215], which is especially critical in urban centers with severe pollution issues. As shown in [216], the electrification of transport can reduce harmful airborne pollutants, a vital factor for public health. Other studies suggest that the environmental and health impacts of transport could be further minimized through the integration of renewable energy sources, V2G technology, and smart charging systems [217]. These approaches not only reduce greenhouse gas emissions but also lessen reliance on fossil fuels [218], a key consideration in the face of potential supply disruptions. The literature also highlights the need for equitable development of EV infrastructure, extending coverage to less affluent areas [219], where electrification can improve quality of life and reduce social inequalities.

Smart Roads

Smart roads employ IoT technology, combining physical infrastructure, such as sensors, cameras, LED lighting, and solar panels, with advanced software solutions, such as AI or Big Data [220]. The concept of smart roads enhances existing road systems to meet contemporary mobility demands, facilitating more efficient transport and vehicle flow, reducing fuel consumption, and improving delivery logistics. These developments provide financial advantages to both businesses and road users while simultaneously supporting sustainable development [221]. In [222], it is additionally pointed out that IoT-based smart roads, integrated with connected autonomous vehicles (CAVs), may enhance traffic safety and the efficiency of transport systems in the future. Other research highlights the ability of smart roads to monitor road surface conditions, warn of hazardous driving conditions, and even report possible maintenance needs or damage [223]. These features are essential not only for user safety but also for maintaining road conditions, particularly in crisis situations. Smart roads also reduce the environmental impact of transport. Study results reveal substantial reductions in energy consumption, pollution, and accident rates on smart highways relative to traditional roadways [224]. Electric road systems (ERS), which power EVs in transit, present additional environmental advantages by providing greater flexibility and convenience for drivers, eliminating the need to stop for charging [225]. The literature also emphasizes the benefits of IoT and machine learning technologies used in smart highways. These roads allow real-time information sharing with drivers, monitor traffic conditions, and provide alerts on potential congestion or incidents [24], which can be crucial for emergency transports. Furthermore, smart roads may have military applications, where WSNs positioned along roadways allow for continuous monitoring to secure transport safety [41].

Green Infrastructure in Transport

The primary aim of green transport infrastructure is to enhance mobility while minimizing the environmental impact of transport. Sustainable travel options, such as cycling and walking, allow individuals to reduce pollution significantly. Cycling, in particular, offers several advantages, including the ability to avoid traffic congestion, eliminate harmful emissions, reduce reliance on non-renewable resources, and promote physical fitness. Additionally, cycling incurs no fuel costs and minimal ongoing costs, making it an economically viable mode of transport. It also enhances road safety by decreasing the volume of cars. However, a well-developed network of bike paths is essential to ensure both safety

and comfort for cyclists [226]. A similar argument applies to walking. Research highlights that pedestrian-friendly infrastructure—designed to be safe, continuous, and accessible to a wide range of users—can significantly reduce car traffic in urban areas, thereby reducing air pollution and noise levels [227,228]. Additional examples of green transport infrastructure cited in the literature include innovative measures, such as photovoltaic noise barriers [229], bus stop roofs covered with vegetation [230], and corridors designed for both wild-life and pedestrians [231]. Each of these solutions contributes to reducing the environmental footprint of transport. In times of health crises, green infrastructure becomes particularly valuable. Studies have shown that opportunities for outdoor recreation and physical activity were crucial for maintaining mental and physical health during the COVID-19 pandemic [232]. Consequently, walking and cycling became essential for public well-being. This underscores the need for strategic planning and development of urban infrastructure to prepare for future crises [233]. The pandemic also highlighted the increased importance of bike sharing, which emerged as a relatively safe, alternative mode of transport [234]. Furthermore, the literature underscores the role of inclusive spatial planning to ensure that green infrastructure is accessible to all social groups, thereby avoiding inequities and fostering inclusivity [235].

Table 12. The role of transport infrastructure solutions in case of potential global crises.

Solution	Role in Case of Potential Crises
Infrastructure for electric vehicles	• Support for the electrification of transport and positive influence on EV purchasing decisions (economic crisis and environmental crisis) • Reducing greenhouse gas emissions and improving air quality, especially in cities (environmental crisis and health crisis) • Opportunity to reduce dependence on fossil fuels through the use of renewable energy (economic crisis and environmental crisis)
Smart roads	• Optimization of transportation, improvement of vehicle flow, reduction of fuel consumption, and increase of supply efficiency (economic crisis and environmental crisis) • Improving road safety (economic crisis, health crisis, and social crisis) • Maintaining the appropriate state of the transport network (economic crisis, health crisis, social crisis, and military crisis) • Reduction of energy consumption and pollutant emissions (environmental crisis and health crisis) • Monitoring traffic and providing real-time information (health crisis) • Possibility to control ongoing transports (military crisis)
Green infrastructure in transport	• Reducing the harmful impact of transport on the environment—lower greenhouse gas emissions and improving air quality (environmental crisis and health crisis) • Positive impact on the mental and physical health of society due to the possibility of safe and comfortable travel by bicycle or on foot (health crisis) • Reducing dependence on traditional means of transport—decreasing road congestion and consumption of conventional fuels (economic crisis and environmental crisis)

4.2.6. Modern Solutions in Vehicles

A comprehensive literature review identified four key innovations in vehicle technology that not only align with sustainable development principles but could also play a vital role in bolstering the economy and transport sector amidst potential global crises (Table 13).

Connected Car

A connected car is an advanced technology that allows vehicles to communicate in real time with the Internet, other devices, mobile applications, and cloud platforms. This connectivity expands possibilities, transforming the driving experience and providing benefits to drivers, passengers, and manufacturers alike [43]. Aligned with sustainable transport principles, this technology also has potential applications in responding to global crises. These vehicles provide real-time road condition updates, optimize routes,

reduce congestion, and relay safety alerts. Connected car technology also enables remote vehicle management, diagnostics, and advanced driver assistance systems (ADAS). By enhancing traffic efficiency and safety, connected vehicles can help reduce transport costs and play a critical role in economic resilience [236,237]. Studies highlight the benefits of connected vehicles in organized truck convoys, potentially reducing operational costs through fuel and route efficiency [238]. This technology also serves as a foundation for connected autonomous vehicles (CAVs), which could address key road transport challenges related to safety, mobility, and environmental impact [239]. Connected vehicle systems also support environmental health, as smoother traffic flow and fewer congestion points lead to lower emissions of carbon dioxide and nitrogen oxides (NO_x). Research confirms these benefits for both CAVs [240,241] and diesel vehicles [242,243]. In public health contexts, connected vehicles facilitate contactless and coordinated deliveries of essential items, such as medical supplies and food, which is critical during epidemic situations [236]. Enhanced with additional detection systems, connected vehicles can also monitor passenger health, improving safety and reducing disease spread in society [244]. Connected vehicles also have the capability to automatically detect and report issues, whether in military convoys or humanitarian missions [245], enhancing overall efficiency and significantly boosting the likelihood of successful logistical operations.

Vehicle-to-Everything (V2X)

Vehicle-to-Everything (V2X) is a next-generation technology, designed to connect vehicles with their entire surroundings, making them integral components of the IoT. Unlike traditional connected car technology, V2X enables real-time communication with other vehicles (V2V), infrastructure (V2I), pedestrians (V2P), networks (V2N), and various electronic devices. The V2X system aims to enhance road safety for all users, optimize route efficiency, and support environmentally friendly driving choices [246]. Given its advanced capabilities, Vehicle-to-Everything could serve as a valuable resource in crisis scenarios. This breakthrough technology has the potential to revolutionize global transport networks, and when integrated with complementary innovations, V2X could further drive economic growth and sustainability [247,248]. The potential of V2X to enhance traffic flow, improve road safety, and support sustainable transport development is frequently highlighted. By enabling real-time data exchange between vehicles and their surroundings, V2X can prevent accidents [188], streamline traffic flow, and lower exhaust emissions [249], thus contributing to a safer, more efficient, and eco-friendly transport ecosystem [250]. Furthermore, integrating V2X with electric vehicles could reduce reliance on fossil fuels and create new job opportunities within the green energy sector [251]. Studies emphasize the significant role of 5G-based Vehicle-to-Everything (C-V2X) in public health, as it facilitates the exchange of health-related data, assisting communities in managing viral outbreaks [252]. Another study found that V2X can help optimize vehicle occupancy, supporting social distancing protocols [253]. Research also underscores the importance of Vehicle-to-Everything in medical and rescue transport by alerting other road users to approaching emergency vehicles [254], while dynamically optimizing routes and reducing congestion to facilitate faster response times [255]. Moreover, V2X supports military applications by providing robust, high-speed communication between ground and airborne means of transport, crucial for responsive operations in dynamic settings [256].

Advanced Driver Assistance Systems (ADAS)

Advanced driver assistance systems (ADAS) are a collection of numerous features that enhance vehicle handling while also improving safety. These systems, depending on the manufacturer, level of advancement, and built-in functions, may include a range of sensors and cameras. Key ADAS functions include lane-keeping assist, emergency braking, traffic sign recognition, driver attention monitoring, adaptive cruise control, and blind-spot warning. With these capabilities, ADAS can effectively monitor, enforce, or correct vehicle behavior on the road [44]. ADAS can be particularly significant from an economic perspective. Research has shown that their use can improve vehicle flow on

highways and reduce travel costs due to lower fuel consumption [257]. Other studies have highlighted ADAS' role in shaping driving behavior, which also results in reduced fuel consumption [258]. Adaptive cruise control and lane-keeping assist are particularly beneficial in truck convoys, enabling them to respond simultaneously to changing road conditions, which improves safety and reduces transport costs [259]. Publications particularly emphasize ADAS' role in enhancing road traffic safety by reducing the frequency and severity of accidents [260,261]. This is especially important, as a lower number of such incidents can reduce public expenditures on addressing their consequences, including infrastructure repairs, rescue services, administrative costs, and hospitalizations [262]. ADAS can also positively impact the environment due to their potential to optimize vehicle speed and reduce fuel consumption. This can limit pollutant emissions, thereby improving air quality [263,264]. Furthermore, given ADAS' essential role in reducing road accidents, it is worth noting that they not only lessen the social and economic consequences of these events but also reduce resource demand. A lower number of incidents can contribute to sustainable development by reducing the need for spare parts or new vehicles, leading to decreased resource extraction and fewer production processes, which translates to lower CO₂ emissions and water savings [265].

Modular Vehicles

Modular vehicles are those with interchangeable components. This modularity is intended to facilitate repairs and maintenance or enable vehicle reconfiguration to adapt it for specific functions. This solution finds application across various industries and sectors, contributing to increased transport efficiency while reducing its harmful impact on the environment [266]. Publications primarily emphasize the importance of modular vehicles in the context of economic benefits related to transport [267], both for cargo and passenger services [268]. By adjusting the vehicle size to real-time needs through module detachment, carriers can cut operational costs. In urban settings, this approach can reduce travel times, fuel consumption, and operational expenses [269]. Additionally, modular vehicles enhance service quality, as they can swiftly reach destinations and seamlessly connect without requiring stops or transfers [270,271]. Studies confirm the environmental benefits of modular vehicles, particularly electric models, over their entire lifecycle [272,273]. This adaptability proves crucial during crises that disrupt transport demand, such as the COVID-19 pandemic [274]. Research also emphasizes the utility of modular vehicles in medical transport, where their customizable structure reduces response times and allows for configuration tailored to specific emergencies [275]. Furthermore, modular vehicles are highly beneficial in military operations. Their design allows for rapid assembly, disassembly, and reconfiguration, enabling fleets to adapt to changing battlefield conditions with greater flexibility and efficiency [276,277].

Table 13. The role of modern solutions in vehicles in case of potential global crises.

Solution	Role in Case of Potential Crises
Connected car	• Lowering transportation costs and increasing road safety (economic crisis) • Reducing pollutant emissions and improving air quality (environmental crisis and health crisis) • Possibility of contactless and coordinated deliveries of goods (health crisis) • Monitoring the health of passengers (health crisis) • Automatic detection and reporting of vehicle failures (military crisis and social crisis)
Vehicle-to-Everything (V2X)	• Optimization of vehicle flow, reduction of fuel consumption, increase of safety of road users, and creation of jobs (economic crisis) • Reducing dependence on oil, coal, and other raw materials (economic crisis, environmental crisis, and military crisis) • Ability to exchange information on the population's health status (health crisis) • Assistance in maintaining social distancing by enabling optimal allocation of passengers to vehicles (health crisis) • Support in medical transports and rescue missions (health crisis and social crisis) • Reliable, high-speed communications between ground and air means of transport (military crisis)

Advanced driver assistance systems (ADAS)	• Improving the flow of vehicles and reducing transportation costs (economic crisis) • Increasing road safety (economic crisis and health crisis) • Lowering pollutant emissions, improving air quality, and reducing the use of resources for the production of spare parts or vehicles (environmental crisis and health crisis)
Modular vehicles	• Reduction of operating costs—lower fuel consumption, increased service level, and reduced travel and waiting times (economic crisis) • Minimizing the harmful impacts on the environment (environmental crisis) • Possibility to adjust the number of available places to current demand (health crisis) • Support for medical and emergency transports (health crisis and social crisis) • Possibility of adapting military vehicles to changing conditions (military crisis)

4.2.7. Advances in Public Transport

Public transport systems are continuously evolving to better meet societal transport needs while minimizing their environmental impact. Several recent innovations also demonstrated potential benefits in global crisis scenarios. A review of the literature highlights five notable examples of such advancements (Table 14).

Autonomous Buses

Autonomous buses are designed to operate independently, relying on advanced technologies, such as sensors, cameras, radars, and artificial intelligence (AI), to navigate and transport passengers safely. As part of the broader category of autonomous vehicles (AVs), these buses are usually electric, fostering a shift toward more sustainable and efficient public transport [278]. One major advantage of autonomous buses is the cost savings from eliminating driver wages. These savings can benefit both transit operators and passengers, potentially lowering ticket prices—an especially valuable aspect in the face of economic challenges and the need for resilience during global crises [279,280]. Autonomous buses also contribute to lower greenhouse gas emissions by optimizing driving patterns, such as braking and acceleration, and utilizing electric powertrains [281], which are more environmentally friendly. This shift could help combat climate change by reducing the carbon footprint of public transport systems [282,283]. In the context of epidemic risks, autonomous buses offer further advantages. They can transport infected patients to healthcare facilities with minimized human interaction or deliver samples and test kits to laboratories [45]. Research also supports the use of autonomous shuttles during fluctuations in passenger demand, highlighting their superior energy efficiency and cost-effectiveness under stringent health and safety protocols [284].

On-Demand Public Transport

On-demand public transport is a flexible transit system that adjusts to individual passenger needs in real time. Unlike traditional transport options, such as buses or trams, which operate on fixed schedules, on-demand services respond dynamically to user requests submitted through mobile apps or booking systems [46]. Research underscores the economic benefits of this approach for transport operators. With the flexibility to adjust to fluctuating demand, service providers can achieve cost savings by optimizing routes and schedules while reducing empty vehicle trips. However, on-demand public transport is noted to be especially beneficial in smaller urban areas, where demand can be more unpredictable [285,286]. Studies on bus transit have shown that on-demand systems reduced average travel times by 30% over a weekly cycle. Additionally, vehicle occupancy rates increased from 8% to over 50%, and emissions per passenger dropped by over 70% compared to traditional scheduled buses [47]. These findings highlight the alignment of on-demand transport with sustainable transport objectives. Other studies highlight the effectiveness of the on-demand system in response to epidemic threats, as evidenced during the COVID-19 pandemic [287]. The primary benefit was the enhanced resilience of the

public transport system to disruptions, enabled by the system's flexible adaptation to varying threat levels and mobility restrictions [146,288].

In-Vehicle Air Quality Monitoring Systems

In-vehicle air quality monitoring systems are sophisticated technologies that enable real-time monitoring and assessment of air quality within the vehicle cabin. Equipped with sensors to measure carbon dioxide, oxygen levels, and other compounds, as well as monitoring humidity and temperature, these systems provide vital information to drivers and passengers, helping reduce health and safety risks associated with extended time in enclosed spaces [289,290]. Air quality monitoring systems can enhance vehicle energy efficiency by adjusting HVAC functions based on current cabin air quality. This helps to lower fuel consumption and, most importantly, energy usage in electric and hybrid vehicles, reducing overall operational costs for transport providers [291]. Research also highlights the importance of this solution for advancing sustainable transport. By managing cabin air quality—particularly in electric vehicles—emissions are reduced both inside and outside the vehicle. This minimizes the need for frequent external air circulation, which in turn helps reduce energy consumption [292]. Most research emphasizes the impact of in-vehicle air quality monitoring systems on passenger health, particularly during health crises, such as pandemics [293,294]. These systems enhance passenger safety by actively monitoring and controlling harmful substances within vehicle cabins. As a result, they help reduce the spread of airborne pathogens, making public transport safer [295,296].

Contactless Payment Systems

Contactless payments in public transport allow passengers to pay for rides using a smart card, mobile device, or contactless bank card, eliminating the need for cash or ticket machines. This method leverages near-field communication (NFC) technology, enabling transactions by simply tapping a card or device on a reader. Another option is digital payment through a mobile app, allowing for a seamless, fully digital transaction [297]. Contactless payments provide numerous benefits for both public transport operators and passengers. By removing the need for paper tickets and cash, transport operators reduce costs associated with ticket production, distribution, and storage. Additionally, automating payment processes minimizes the need for ticketing staff, yielding further savings. For passengers, contactless payments offer speed and convenience, shortening wait times at stops, accelerating boarding, and removing the need to carry cash or physical tickets. This convenient system encourages greater public transport use, potentially boosting revenues and decreasing reliance on private vehicles [298,299]. This shift has a positive impact on urban air quality by reducing greenhouse gas emissions from transport. Research also highlights the role of contactless payments in promoting public health, particularly during epidemics [300]. The COVID-19 pandemic underscored the importance of contactless payments as a crucial element in enhancing sanitary safety for travelers. This solution eliminated the need for contact with staff [301], cash handling, and using ticket machines, thereby reducing the risk of virus transmission [293,302].

Smart Stops and Stations

Smart stops and stations are innovative public transport solutions that leverage information and communication technologies (ICTs) to improve travel comfort and safety. Equipped with interactive displays showing schedules, mobile payment options, monitoring systems, and traffic management, these stops provide passengers with better access to information and services, enhancing the quality and safety of public transport [48,49]. Beyond economic benefits, smart stops and stations are also environmentally friendly. They provide real-time traffic information, boosting transport efficiency and passenger comfort by allowing for better travel planning, with updates on possible schedule disruptions [303]. A key advantage of smart stops and stations is their accessibility, as the infrastructure and informational interfaces can be customized to meet the needs of diverse user groups, including the elderly, disabled individuals, and immigrants. By eliminating

barriers, these features can drive higher demand for public transport across all demographics [304]. Research emphasizes the environmental aspect of designing smart stops and stations. Studies advocate for solutions such as smart lighting management and photovoltaic panel installations, with additional support from the public power grid [305]. These innovations, especially when aligned with smart city concepts [49], can significantly reduce energy usage, lower local CO₂ emissions, and contribute to better air quality.

Table 14. The role of recent advances in public transport during potential global crises.

Solution	Role in Case of Potential Crises
Autonomous buses	• Lack of expenses for operators to employ drivers and the possibility of reducing transportation costs (economic crisis) • Reducing greenhouse gas emissions and lower carbon footprint (environmental crisis and health crisis) • Possibility of using it for contactless transport of infected people, samples, and tests (health crisis) • Higher energy efficiency and profitability of transport during sudden fluctuations in demand (health crisis)
On-demand public transport	• Possibility to generate savings by flexibly adjusting courses, shortening travel times, and increasing vehicle occupancy (economic crisis) • Reducing harmful gas emissions per passenger (environmental crisis and health crisis) • Increasing the resilience of the public transport system to potential sudden changes in demand for passenger transport (health crisis)
In-vehicle air quality monitoring systems	• Lowering the costs of running transportation operations—less fuel or energy consumption (economic crisis) • Reduction of fuel or electricity consumption (environmental crisis and health crisis) • Increasing passenger safety through the ability to monitor air quality and reduce the spread of viruses (health crisis)
Contactless payment systems	• Lower costs related to the production, distribution, and storage of tickets, and no need to engage employees to conduct sales (economic crisis) • Increased demand for public transport travel due to speed and convenience of payment—decrease in use of private vehicles (economic crisis and environmental crisis) • Higher sanitary safety of travelers by eliminating contact with staff, touching cash, and using ticket machines (health crisis)
Smart stops and stations	• Increase overall transportation efficiency and improve comfort for users (economic crisis) • Support in terms of accessibility for different user groups (economic crisis and social crisis) • Reducing greenhouse gas emissions and improving air quality through integration with other innovative solutions (environmental crisis and health crisis)

5. Conclusions

5.1. General Summary

The modern world remains exposed to a range of threats, which, as recent decades have shown, can lead to severe consequences and global crises. Additionally, ongoing environmental degradation and disruptions to the climate system exacerbate these problems, causing negative impacts on human health, the economy, and society. The goal of this publication, which was to identify the latest solutions in sustainable transport development and to highlight their relevance in the context of potential global crises, has been achieved. The results not only identified solutions crucial for the stability of the economy and transport sector in crisis situations but also suggested future research directions in this area. Moreover, these findings can serve as a resource for policymakers and transport organizers in implementing actionable recommendations.

5.2. Practical and Theoretical Contributions

This study offers a valuable practical contribution by presenting a series of transport solutions that, while aligned with the principles of sustainable development, primarily aim to enhance transport resilience to potential global crises. The results presented in the paper contribute to the sustainable development of transport by identifying the latest

technological solutions that can reduce greenhouse gas emissions, promote energy efficiency, and improve safety and increase the overall stability of the transport sector. Innovations such as alternative drives, autonomous vehicles, and intelligent traffic management systems can significantly reduce the carbon footprint and ensure the continuity of transport services even during crises, such as financial breakdowns, epidemics, or armed conflicts, while reducing dependence on fossil fuels and increasing the reliability of logistics. Emission monitoring systems allow improved air quality, which is important in health crises, such as the COVID-19 pandemic. Autonomous technologies, such as unmanned vehicles and drones, can support logistics during crises, delivering medicines or other resources to dangerous or isolated regions. It is also worth pointing out the benefits of this study for future vehicles. The results showed that means of transport, such as AVs, alternatively powered vehicles, or modular vehicles, consistently developed toward compatibility with intelligent transport systems, can optimize traffic, reduce energy consumption and harmful emissions, and become more integrated with the infrastructure. Moreover, vehicles could benefit from the expansion of charging infrastructure, including stations using renewable energy. As a result, this would reduce the dependence on traditional fuels and the negative impact of transport on the environment. The article provides a practical foundation for decision-makers and transport organizers, offering recommendations on which solutions can be implemented to make the transport sector more resilient and environmentally friendly. Possible future actions can include testing and popularizing intelligent fleet management, expanding green infrastructure, and continuing work on integrating V2X-related technologies. A further step could be the implementation of autonomous solutions and the popularization of modular vehicles, which is justified due to their ease of adaptation to changing crisis conditions and increased resilience of transport systems.

The theoretical contribution of this study includes definitions, examples, and classifications of modern transport solutions, as well as the characterization of global crises. The concept of sustainable transport development was also discussed in detail, including the principles that should be met. The literature review allowed for the identification and categorization of specific transport solutions into categories, such as powertrain technologies, intelligent transport systems (ITS), logistics and delivery innovations, integration of transport systems, infrastructure development, modern vehicle solutions, and advances in public transport. This publication also provided a characterization of recent global crises and a classification that included economic, health, environmental, social, and military crises. As a result, this approach established a theoretical foundation that facilitates an understanding of the application of specific transport solutions in the face of potential global crises and underscores their importance for sustainable transport development.

5.3. Limitations and Further Research

This study faces several limitations that may affect its findings. First, the source selection was restricted by publication date. Since the review focused on recent research advances, only literature published from 2020 onwards was considered. This choice may have overlooked older, yet still valuable, studies on sustainable transport solutions relevant to potential crises. Another limitation is that the review drew exclusively from available scientific publications. Consequently, the findings may not fully capture the real-world challenges of implementing the proposed innovations, potentially overlooking obstacles, such as societal resistance to new technologies. There are also limitations related to source selectivity, as the review was based on research from only four scientific databases. This approach may have excluded other significant studies in less widely used databases or articles not indexed in these databases. Therefore, the review may not present a complete picture of the current state of knowledge on the topic.

This study also indicated possible directions for future research in sustainable transport solutions, which are also relevant in the context of possible crises. Given the results obtained, empirical studies on the effectiveness of implementing individual

innovations based on geographical location and social diversity would be appropriate. These analyses could examine cost–benefit assessments, environmental impact, and societal acceptance of these solutions. Another critical area for future research involves developing hypothetical scenarios to prepare the transport sector for various crises and associated disruptions. The literature review also highlighted the importance of advancing research on the integration of autonomous technologies with urban infrastructure due to their potential to reduce emissions and improve energy efficiency. Finally, investigating the impact of international cooperation on transport technology development would be beneficial, particularly regarding access to renewable energy sources, legal regulations, and potential trade barriers.

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