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# A Review of the Promotion of Sustainable Mobility of Workers by Industries

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**Abstract:** The evolution and growth of cities present considerable challenges to the promotion of sustainable mobility, namely in commuting trips. In the present and recent past, many industries and companies of the economy's productive sector have had to move as far as possible from urban areas, to minimize the impact of their activities on people's health and quality of life. In more dispersed and low-density territories, working and residential areas are very far from each other, and there is typically poor public transport service and a lack of cycling networks for commuting purposes. This scenario encourages the use of private automobiles, not only as a necessity but also often as an obligation, making the mobility system nearly unsustainable. Therefore, it has become clear that companies can play an important role in promoting more sustainable mobility by reducing car use on commuting trips and by offering employees clean and more efficient transport alternatives to promote workers' well-being and quality of life. Through an extensive literature review, a selection of scientific articles in the last 13 years was analyzed and discussed. The results highlighted that the location of industrial areas, the supply of public transport, the usage of active modes, and shared mobility systems are key factors to reduce car usage in workers' commuting trips. Therefore, any sustainable mobility strategies that companies adopt will minimize the respective negative externalities, helping promote more environment-friendly ways of transportation, accessibility, social equity, and inclusion in workers' communities. This justifies the need and urgency for the development of specific sustainable mobility plans oriented for companies/industries, instead of addressing this as just another element of a conventional urban mobility plan. Since this mobility represents a high volume of trips, repeated according to very regular patterns, it must be sustainability-oriented, allowing the improvement of system, trip, and vehicle efficiency.

**Keywords:** sustainable mobility; commuting; worker's mobility; industries; companies



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## 1. Introduction

Throughout the ages, the evolution of the territory, particularly in terms of land occupation, has undergone several changes in an attempt to respond to the needs and ensure better living conditions for societies. In this context, the industry was being reorganized and concentrated, whenever possible and desirable, in areas of industrial reception to guarantee optimization of the use and share of the resources and infrastructures between the different types of companies to gain efficiency and reduce production costs. In addition, as a result of the potential incompatibility between industrial activity and human experience, industries were being allocated in areas increasingly distant from urban areas, to minimize the impact on the quality of life of ecosystems and the population in general. This distancing has made commuting from home to work (industry) very dependent on motor vehicles, especially and mostly on cars [1,2].

Production processes are essential for the useful life of industries. These processes are usually oriented to increase the efficiency and effectiveness of measures aimed at mechanization, professionalization, automation, and control of productive activities within the

factory, eventually passing to a second plan of intervention the satisfaction of the employees' needs that go beyond the issues of the factory floor. Yet, the location of the industrial park relative to the urban areas determines, to a certain extent, the conditions of access, especially in terms of the supply of infrastructure and transport services, i.e., the mobility of employees (workers) of companies in their daily commutes from home to work [1,3].

However, it is important to emphasize that workers' mobility issues play an important role in the productive capacity of the company itself since their well-being will influence their productivity and, eventually, the final quality of the products. Thus, the mobility of workers can and should be considered a crucial aspect to guarantee more suitable working conditions and health for all workers, in addition to being able to leverage high levels of adherence to the goals and vision of companies, particularly when it is intended that companies want to introduce and foster technological dynamics and sustainability into their manufacturing processes [4,5].

Mobility management defined by Farahmand et al. [6] is "any action or set of actions aimed at influencing travel behavior in such a way that sustainable mobility options are presented and car trips are reduced".

The regularity and quantity of trips generated in commuting from home to work, especially if these were made by car with a combustion engine, present a set of negative externalities to society that must be minimized, particularly in environmental terms, both in terms of energy, noise, pollutants, and greenhouse gases emissions, such as $CO_2$ (Carbon dioxide). In this way, one of the action vectors to improve the overall sustainability of industries is mobility, particularly of its employees, which is intended to lower environmental, economic, and social impacts, on the company's universe and society in general [6,7].

Although industries do not usually control or can condition the way their employees commute or travel, they can stimulate and promote a more sustainable culture through incentives for the use of public transportation or active modes, promoting the use of less polluting individual motorized vehicles, or even through more current and innovative measures that involve ridesharing or pooling and restricting the use of cars with combustion engines (diesel and gasoline), particularly those with very low occupancy rates [8].

Therefore, through a literature review on the topic under study, this article aims to analyze the existing scientific production with an approach to the workers' mobility behavior and the role of the industries in promoting more sustainable ways for its employees. Through a search on online platforms, 758 articles were found between the years 2009 to 2022, after the methodological screening requirements, 32 articles were selected for this study. With this, there was a clarification of this subject, consolidating the ideas found in the literature that also serve as a basis for future discussions and research. Among the main discussions were the important contribution of the company in promoting its employees to more sustainable ways through strategies of bonuses and benefits, reduction of the number of spaces in the company's parking lots, and incentives to a healthier life with benefits for people and the planet.

Thus, the following topics were considered and selected: the location of the company, parking infrastructure, behavioral analysis of employees, and promotion strategies for more sustainable modes. To understand, analyze and propose modes of sustainable mobility for industries through these themes.

Considering the current model of mobility, land use and occupation, is it possible to develop a set of actions and strategies that modify the modes of transport of industry employees so that mobility becomes more sustainable?

This work is developed in six sections, including this introduction. The second section presents a contextualization of the terms used in this study, then, the third section presents the materials and methods adopted in the selection of articles from the literature. The fourth section considers the main results found, strategies, and actions for commuting. In section five, the discussions related to the mobility of workers are discussed, and finally, in section six, the main conclusions are described in the last section.

## 2. Context and Framework

### *2.1. Sustainable Mobility*

The term sustainable development began to be used in 1987 with the Brundtland report, intending to meet the needs and aspirations of the present without compromising the future. In 1992, the UN's Agenda 21 in Rio de Janeiro was the milestone for defining the principles for sustainable development worldwide. In 2001, the European Union adopted measures for the implementation of sustainable development policies in member countries, and by 2030, the objectives described in the 2030 Agenda, related to sustainable development, must be implemented [9].

With the growth of cities and the consequent increase in demand for mobility, there has been an increase in the number of cars, traffic, and emissions. These negative impacts caused in cities, derived from urban mobility, due to the high dependence on the individual car for commuting, must be reduced. The 2007 European Commission Green Paper on Urban Mobility, promotes the use of sustainable public transport [9].

With the Paris Agreement signed on 21 April 2016, by 175 countries and the European Union to limit global warming, countries should achieve the global target of greenhouse gas emissions in addition to economic and social transformation [1,10].

Since 25 September 2015, a summit held in New York has defined 17 goals for global transformation to take place through the sustainable development of the planet and that can promote the reduction of inequality between people. Of these 17 goals, 169 targets are directly or indirectly related to the mobility of people and the sustainability of industries. Through the creation of a sustainable infrastructure to support human development, and even in the rehabilitation of industries making them more sustainable, with clean technological processes that respect the environment [11,12].

In this context, transportation systems will have to transform the way they are planned, operated, and managed, so that negative externalities are reduced and, if possible, eliminated. Aiming to improve sustainability levels and reduce the current transportation system's negative externalities, including atmospheric and greenhouse gas (GHG) emissions, noise pollution, and congestion [1].

With the European Green Deal, the European Union has set a goal to reduce 90% of transport emissions by 2050, creating intelligent, competitive, safe, and accessible transport systems [11].

Policies adopted in other non-European Union countries, for example, may offer contributions to improving global mobility conditions, such as the Norwegian White Paper 26, from the period 2018 to 2029 (National Transport Plan), describes that any future growth in urban private transport must be absorbed by public transport, walking and cycling [10].

The increase in the amount of fossil fuel burning in internal combustion vehicle engines leads to emissions of various types of harmful gases into the atmosphere known as GHG. The $CO_2$ in large quantities contributes to the increase in the average temperature of the planet, accelerating the process of global warming. The transport sector alone is responsible for 1/3 of greenhouse gas emissions worldwide [12].

Among many possible actions that have been applied in terms of transport policies, we can highlight: (a) the reduction of car use levels; (b) the adoption of soft modes, such as walking or cycling; and, (c) the promotion of the use of public transport.

The sustainable mobility approach requires actions to reduce the need for the number of trips, encourage modal shifts, reduce travel time, and encourage greater efficiency in the transport system. However, there is also a need to understand behavior and explore how cooperation and support can be obtained so that a modal shift change can happen [13].

Sustainability tends to support transport thinking and changes that result in a more diverse and cost-efficient transport system, with less impact on land use and reduced dependency on the automobile. These changes have contributed to economic efficiency, resource reduction, and negative environmental impacts to improve mobility for non-drivers [14].

With the evolution of the goals and objectives of sustainable development initiated in the Brundtland Report, it is worth emphasizing the importance of the sustainable mobility

of industries in this context. The industry has the role of influencing the travel pattern of its employees, stimulating them towards a new perspective of a more sustainable transport option in their commuting [15,16].

### *2.2. Demography, Urbanization, Mobility, and Industrial Location*

Understanding population changes is a prerequisite to success in a planned sustainable development process, especially when it is intended to be implemented following the 2030 Agenda for Sustainable Development defined by the UN [9].

The world's population grew faster in the period between 1962 and 1965, with an average increase of 2.1% per year. Since then, the pace of population growth has slowed down, by more than half due to low birth rates. In 2020, for the first time since 1950, the population growth rate dropped by 1% per year and it is estimated to continue to decline in the coming decades. However, it is estimated that this population could grow to about 8.5 billion inhabitants by 2030 and 9.7 billion by 2050. Therefore, this demographic change is not the same throughout the world, and it is still possible to observe population growth in some countries of the African, Asian, and South American continents, and a decrease in other countries in Europe and North America. In 2020 and 2021 the population of Europe and North America stagnated at a rate close to zero percentage points. Between 2022 and 2050, the population of 61 countries is expected to decrease [17].

Parallel to population growth, is the phenomenon of urbanization, making it possible to observe that cities house more and more inhabitants and, consequently, the consumption of natural resources increases [18–20]. According to Leite and Awad (2012), "Cities consume more and more energy and are increasingly responsible for global $CO_2$ emissions. Between 1950 and 2005, the world's urban population grew between 29 and 49 percent, and the global carbon emission jumped from 1630 to 7985 million tons". To counteract and mitigate the negative effects of this trend, it is necessary to adopt preservation policies and spatial organization that aim to transform cities into increasingly sustainable territories [20–22].

The trend toward urbanization of territories is fueled by migratory movements. At the end of the 18th century, there were the first migratory population processes, where people left the countryside in search of better opportunities and living conditions in the cities, originating the great metropolises. Along with this movement, in the early nineteenth century, the process of segregation of production areas to the outskirts of cities began, where the industry abandoned the urban centers and moved to new industrial spaces further away from the urban areas. This industrial shift led to a movement of workers from their living areas to their workplaces, intensifying the commuting between home-work-home [21,23].

The location of industrial areas, often, far from residential areas, does not ensure good levels of accessibility and mobility of workers to their workplaces, becoming a challenge for planners and managers of territory and mobility and transport, to develop an effective mobility planning that meets the needs of workers [2,22,24,25].

In this context, the concept of spatial or geographic mobility arises, which corresponds to recurrent displacements between the workplace and housing (commuting migration), including movements destined for shopping and leisure activities, or, even, that result in seasonality. natural with repetitive characteristics and with a certain daily regularity [11,22,26].

### *2.3. Commuting Mobility to Work*

Mobility to work or to workers is an integral part of urban mobility, and may have a pendulum characteristic (movements similar to a pendulum that are repeated in both directions home-work/school and work/school-home), and are present with considerable regularity [27].

The journeys of workers/employees, visitors, and service providers constitute a significant share of the usual daily journeys of a society. Therefore, travel generating/attraction hubs play an important role in the field of mobility management and system sustainabil-

ity [15,28]. The importance of companies in encouraging good mobility practices among their employees, both in helping actions for behavioral changes as well as benefits and supporting to encourage the change of sustainable modes of transportation [1].

According to Petzhold et al. [8], although companies cannot control the way their employees go from home to work, they can encourage a change in mobility habits, through incentives for the use of more sustainable, collective, clean transportation or even healthier ones like cycling or walking.

According to Bartle [25], public authorities generally seek to involve companies in encouraging the use of more sustainable transport by their employees. On commuting trips, companies are seen as mediators to encourage the reduction of car use (individual transport) by their employees.

Commuting represents a challenge for urban areas, especially when automobile use is predominant, due to environmental problems, land use, and occupancy. On the other hand, the choice and adoption of different modes of transportation are related to the form, frequency, and type of trips. Therefore, this modal shift from individual to public transportation is made more difficult when multiple work and family trips must be met [8].

Still in commuting, in a recent study of the city of Oslo, Norway, it was found that employees did not choose jobs by their proximity, but by travel time, even if the jobs were better [10].

Labor legislation regarding employee mobility is stronger in Europe than in the US and the UK. In Belgium, for example, transport subsidies are agreed upon between workers and employers. Travel costs are considered a tax-deductible expense in Belgium, as expenses in Belgium, Denmark, Finland, France, Germany, and the Netherlands. In Portugal, expenses related to the acquisition of monthly passes for the use of collective public transport can be deducted from the Personal Income Tax (IRS). In the United Kingdom, in an investigation on mobility for employees of 20 companies, it was possible to verify that only 6.2% of the interviewees classified that companies are highly responsible for the transport of their employees and that companies' mobility plans present good results in the reduction of car use on commuting to work [25].

In a university context, commuting has similar characteristics to industrial workers. Class schedules, living close to the university, and public transport costs determine students' choice of transport mode [29].

Given the articles related to this study, there is a need for more work related to mobility in industries and it is necessary to exhaustively deepen more research on employee mobility and dependence on car use on work trips.

## 3. Research Methodology

The literature review was carried out through a search of scientific articles published on online platforms. For this research, Scopus, Science Direct, and Google Scholar were used, which are the most comprehensive databases for academic research purposes [19,30].

A methodological and systematic process was used for the selection of articles already consolidated by Ribeiro and Castañon, consisting of three steps: (1) search in the databases by keywords, defined according to the subject of the theme of the study; (2) screening process by correlated areas and by the analysis and reading of the abstract; and (3) analysis of the article through its complete reading and inclusion of the document [19,20]. For a systematic review of the literature, the traditional method was used, which allows a deep understanding of the literature, identifying gaps in the research in a qualitative and subjective way [31].

The following is a schematic flowchart (Figure 1) of the selection of studies for the literature review.

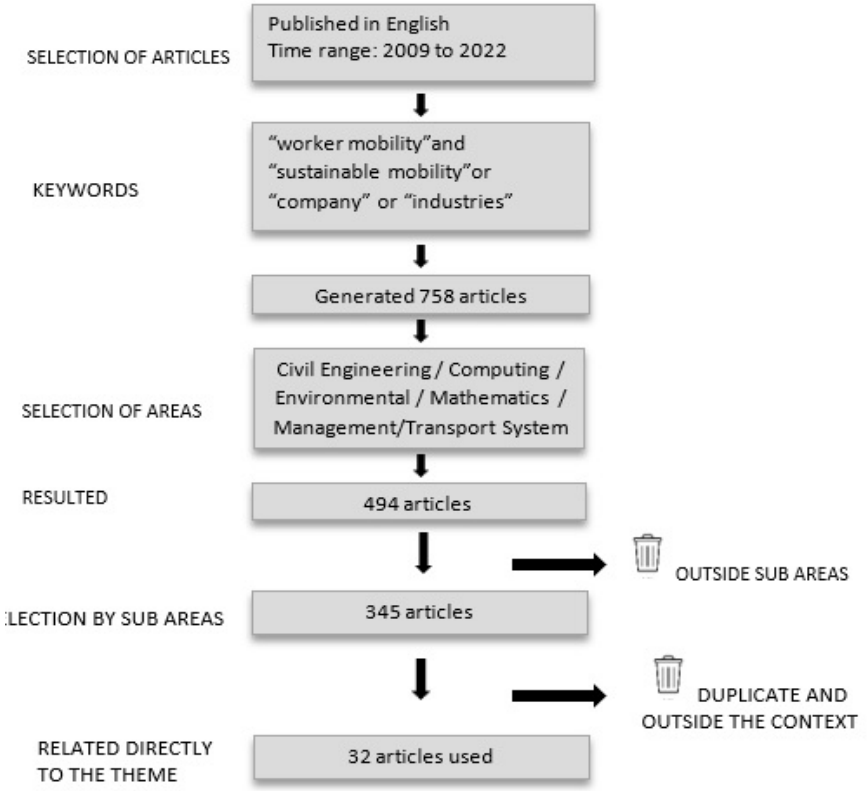


**Figure 1.** Flowchart of the article selection methodology.

The article was collected on the research database platforms through the online search engine in March 2022. This survey was carried out using the following keywords: "worker mobility" and "sustainable mobility" or "Company" or "industries", using a reference period for publications of 15 years, i.e., between 2009 and 2022, The graph in Figure 2 shows the evolution of articles published within the scope of this theme for the period of the last 20 years in the databases Google Scholar, Science Direct and Scopus, being possible to verify that it is only in the last 15 years that the theme has been the target of a dedicated investigation, thus justifying the period defined for this work.

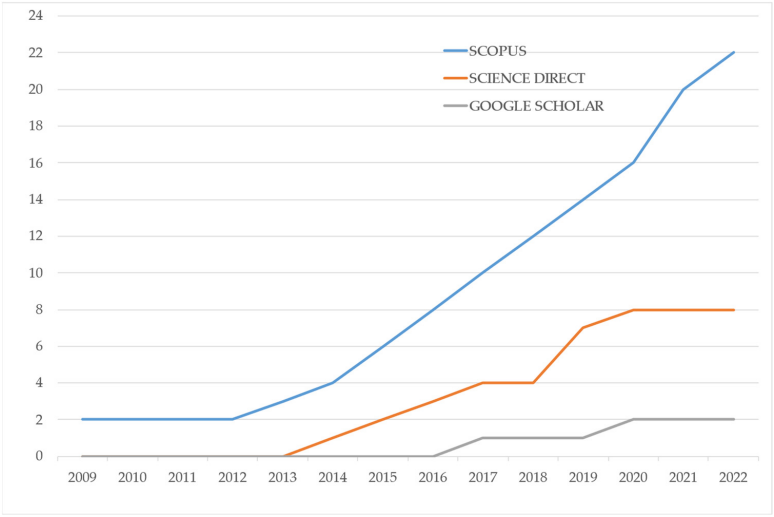


**Figure 2.** Sustainable mobility of workers by industries query-related documents by year (source: Scopus, Science Direct, and Google Scholar).

The initial search generated 758 articles/documents all related to the specified keywords. The areas of medicine, nursing, chemistry, agricultural and biological sciences, social sciences, physics and astronomy, biochemistry, and veterinary were excluded from this set of articles. 494 articles remained in the areas of civil engineering, management, transport systems, and mobility. After this, a selection was made through sub-areas: commuting, corporate mobility, and workplace mobility. Thus, 345 articles remained, in which a new selection was applied, removing the duplicates and those not related to the main theme, by reading the summary. At this stage, articles were selected that addressed behavioral changes in modes of transport in groups of workers and strategies used to promote more sustainable mobility between home and the workplace. In the end, 32 articles/documents remained. In addition to these articles, this literature review used some gray literature documents such as legislation, decree-laws, laws, and others related to urban mobility.

## 4. Results and Analysis of Selected Documents

### *4.1. Main Themes of Analysis*

To systematize the reading and analyses of the articles in an organized manner six main themes related to this study were defined, therefore the selected articles were classified as follows.

(a) Commuting and sustainable mobility (CSM): addresses definitions of sustainable mobility and home-to-work commuting were selected.
(b) Company location (CL): addresses the influence and relative (distance and time) location between workplaces and workers' residences in transport modal choice for commuting purposes.
(c) Car supply infrastructures in companies (Park): this theme focuses on the issue of parking available at, or next to, industries, especially those who addressed the existence and quantity of parking at the workplace, as well as the taxation or not of this supply.
(d) Modal choice behavioral analysis (Beh): addresses modal shift issues, especially those that focused on behavioral changes namely for healthy modes of transport such as the soft modes or more efficient modes such as public transport.
(e) Strategies for promoting sustainable mobility (SfSM): this theme focuses on promoting sustainable mobility of workers in their daily trips through the planning and implementation of strategies and measures like Sustainable Mobility plans, promoting carsharing and carpooling, Transport Demand Management (TDM) or even solutions on Mobility as a Service (MaaS), and other mobility measures.
(f) Others (OT): This theme integrates more general issues like methodologies, history, population issues, and environmental questions mainly related to emissions in commuting trips.

The following table (Table 1) shows the number of articles researched per main topic. A large majority of the selected articles were case studies (CS), pilot experiments (PE) and literature reviews (LR), and others (OT).

**Table 1.** Author and Subthemes.

| Author | Commuting and Sustainable Mobility | Company Location | Car Supply Infrastructures in Companies | Modal Choice Behavioral Analysis | Strategies for Promoting Sustainable Mobility | Other | Method |
|---|---|---|---|---|---|---|---|
| Abrahamse et al. [32] | | | | x | | | PE |
| Agência Portuguesa do Ambiente [21] | | | | | | x | OT |
| Aguiléra et al. [23] | x | x | | x | | | PE |
| Aguiléra et al. [33] | x | x | | x | | | PE |
| Banister [13] | x | | | | x | | LR |
| Bartle et al. [25] | | x | x | | x | | PE |
| Becker et al. [34] | | | | | x | | CS |
| Cass et al. [22] | x | | | x | | x | PE |
| Castañon et al. [19] | x | | | | | x | LR |
| Christiansen et al. [35] | | | x | | | | PE |
| Coriolano et al. [26] | x | | | | | | CS |
| Diniz et al. [27] | x | | | | | | CS |
| Engebretsen et al. [2] | x | x | | | x | | CS |
| Ermans et al. [36] | | x | | x | | | LR |
| Ermans et al. [37] | x | x | | | x | | CS |
| Faccio et al. [7] | | | | x | x | | LR |
| Farahmand et al. [6] | x | | | | x | | CS |
| Fonseca [38] | | x | | | | | CS |
| González et al. [29] | x | | | x | | x | CS |
| Gorges et al. [1] | | x | | | x | x | LR |
| Guzman et al. [39] | | | | | x | | CS |
| Havet et al. [40] | | | | x | | | PE |
| Ho et al. [41] | | | | | x | | CS |
| Hosseini et al. [30] | | | | | | x | LR |
| IMTT [15] | x | | | | | | OT |
| Julsrud et al. [10] | x | x | | | | | CS |
| Korsu et al. [28] | x | x | | | | x | PE |
| Kwoka et al. [42] | | x | x | | x | | CS |
| Leite et al. [18] | | | | | | x | OT |
| Lee et al. [3] | x | | x | | | x | CS |
| Lima et al. [27] | | x | | | | | CS |
| Menendez et al. [14] | x | | | x | | | CS |
| Meurs et al. [43] | | x | | | | | PE |
| Petzhold et al. [8] | x | | | x | x | | LR |
| Pfertner et al. [11] | | | | | | x | CS |
| Ribeiro et al. [20] | | | | | | x | LR |
| Rosenfield et al. [44] | x | | x | | | x | PE |
| Santos et al. [12] | | | | | | x | LR |
| Schaller et al. [45] | | | | x | x | x | CS |
| Schikofsky et al. [46] | | | | x | x | | LR |
| Sener et al. [47] | | | | x | x | | CS |
| United Nations [5] | | | | | | x | OT |
| United Nations [17] | x | | | | | | OT |
| Vale et al. [48] | | | x | | | | CS |
| Witchayaphong et al. [49] | | x | x | x | | | CS |
| Zapolskytė et al. [9] | x | | | | | x | CS |

Methods: CS = Case Study, LR = Literature Review, EX = Experiment, OT = Others.

After separating the articles studied by themes, the publications were analyzed by year and were graphically produced in Figure 3.

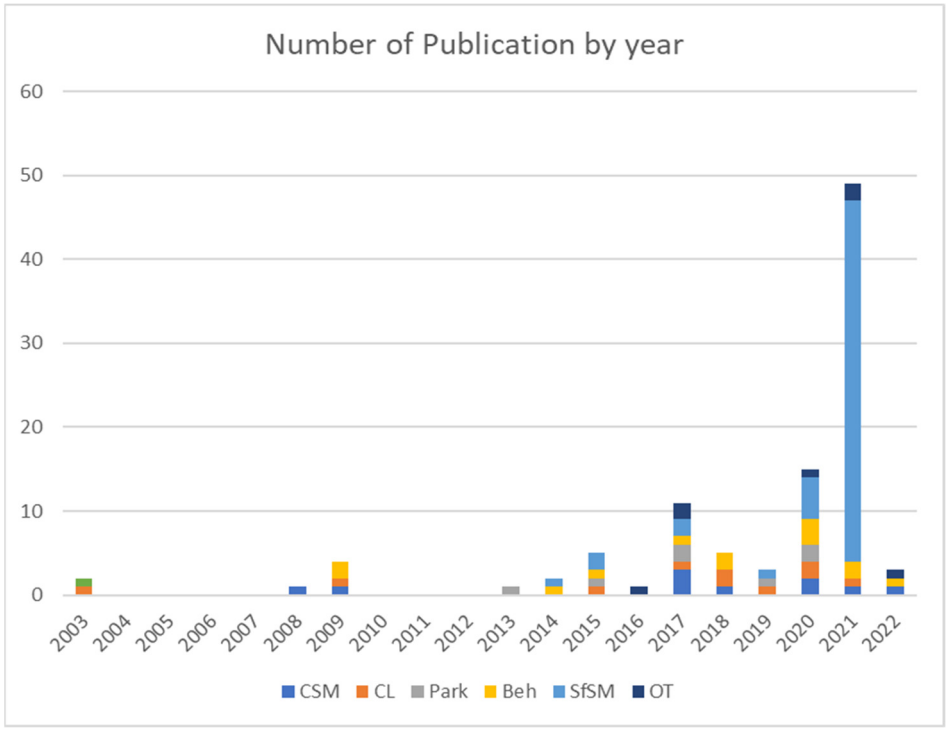


**Figure 3.** Query-related documents by year.

According to the chart in Figure 3, most selected documents are on the Scopus platform from 2015 onwards. There is an increase in documents in Science Direct in 2019. On the other hand, it must be emphasized that there has been a growth in publications since 2015 with the most addressed subtopics such as behavior, parking, and actions in the mobility plan.

### *4.2. The Role of the Location of Companies Relative to Residences in the Modal Choice of Workers*

Spatial planning can promote more sustainable mobility through planning and developing economic activities by limiting urban sprawl and housing density, integration, and connection of places of activity of companies and residences [36].

The location of a company's facilities is an important indicator for the implementation of the mobility management concept and reduction of negative externalities in the transport system for home-to-work commuting movements since they always correspond to the starting and/or ending point of these trips [1]. From the oil crisis onwards in the 1970s, USA employers began to adapt their mobility management strategies with the use of alternative transport in exchange for the private car. This measure was intended to improve air quality and traffic congestion and lasted until 1990. In the same period this concept was transferred to Holland and soon to other European countries with a certain evolution [1]. In some countries there are regulations requiring the implementation of work mobility management plans, in the United Kingdom this happens when the employer requests permission for new premises. In the USA, employer transportation plans were regulated in the 1980s and 1990s where they mandated all employers with more than 100 workers and located in districts with more than 150,000 people. Although many of these regulations have disappeared, however, the USA is the country with the highest regulation, compared to European countries in travel planning [25].

The term land/soil use refers to man's relationship with the land and his activities in this space. The road network, parking lots, buildings, and public facilities are physical

aspects of urban design that interact with people. The demand for transport in this space will depend on the activities carried out in the journeys for shopping, school, work, health, or leisure [43].

According to Fonseca [38], Industrial Areas (IAs) are planned and pre-qualified places to accommodate companies, offering the necessary infrastructure for the implantation, installation, and all production processes. The first cases of IAs emerged in the UK, USA, Germany, and the Netherlands in the late 1890s, with the idea of having a physical separation between industrial areas from residential areas, keeping polluting companies away from residential spaces and also, and destroying the old system without criteria where growth was ungoverned. The success of companies in their host areas depends on favorable conditions for their installation, highlighting good accessibility for employees, adequate logistical infrastructure, and the existence of good connections between residential and production areas.

In the Brussels region, there is a tendency to increase the average distance between home and work, with this, leading to an increase in the use of individual cars to cover greater distances and an increase in car speed [37].

In another context, a study in the city of Denver, Colorado (USA), involving 16,000 people and 80,000 trips, found that living close to a public transport station, by itself, does not justify the use of alternative modes for commuting. But if the destination (work) is located close to a public transport station, it was found that people are less likely to use a car on this commute to work [42].

On the other hand, the location of the company and the supply of public transport has a great influence on the recruitment of new employees. In an investigation carried out in two major employment centers on the outskirts (9 km from the center) of Bristol, England, it was possible to verify a certain difficulty in recruiting employees, in technological areas, who would earn lower wages and with less ability to own a car. It was also found that the most skilled jobs are increasingly concentrated in the city centers, while less qualified jobs are dispersed and further away from the urban centers. However, the location of companies in the outskirts usually has good road access, but public transport services are precarious, making access difficult for workers [10,25].

Access to alternative means of transport contributes not only to the reduction of air and noise pollution and congestion but also to better access to employment [9].

Although the impact of distance is variable, there is a relationship between the workplace and the modes of transport used for this purpose. Thus, for workplaces located in the suburbs, travel was carried out by car, while for workplaces in the city center, public transport was already used more frequently. On the other hand, the most relevant individual characteristics of employees are those of a sociodemographic nature, e.g., gender and the number of children, showing that female employees and/or those with children tend to travel shorter distances to jobs [2].

The rate of use of public transport depends on the quality of the offer and the existing service and can be attractive even for high-income residents, that is, with access to a car. There is a strong relationship between transport policy and land use, depending on the choice of means of transport for commuting from the workplace and, more precisely, on how homes and workplaces are connected [33].

Transport and mobility costs are key factors that affect the potential location of economic activities. The reduction of intercity transport costs could induce the concentration or dispersion of production factors. The shorter travel time caused by the development of transport technologies may result in population dispersion to suburban areas [3].

### *4.3. Car Infrastructures in Companies—Parking Issues*

The lack of availability of parking spaces at workplaces is one of the most effective ways to reduce car use for commuting to work. According to Christiansen et al. (2017) [35], the availability of free parking quadruples the chances of employees using their cars to travel home to work. In contrast, the availability of free but limited on-site parking halves

the chances of car use compared to the availability of free and easily accessible parking. Furthermore, when parking restrictions are combined with the use of public transport, the results are more favorable. When referring to parking at the place of residence, it shows that greater distances between the residence and residential parking significantly reduce the use of the car as a means of commuting, so much so that the city of Stavanger in Norway adopted this rule in the regulations on land use [35].

Belgian companies recognized that parking is an important issue to increase the effectiveness of the measures used by companies, as well as car sharing in suburban areas. In this context, tougher measures such as charging parking fees were used, as they were more effective than lighter measures, such as deductions from taxes related to the use of public transport [36].

Another example is the study on the relocation of a company to the outskirts of Lisbon, it impacted an increase in private car use, and demand management measures were required in addition to reducing or eliminating free onsite parking [44,48].

Bartle et al. [25] comment on the importance of mobility management plans in the UK workplace, where employers are encouraged to implement measures to improve mobility by encouraging their workers to use alternative modes of travel, among others. This plan, called Workplace Travel Plans, has as its main objective to reduce the demand for parking lots where capacity is limited, usually in large urban centers, so that environmental goals could be also met. Research carried out in an area on the outskirts of Bristol, around 9 km north of the city center, presents an example of a reduction in the proportion of parking spaces for company managers. These employees, despite being disaffected, were more likely than other workers to change to sustainable transport and also realized the importance of this change for the company's overall performance.

For mobility changes to take place in companies, employees must be involved in the transformation through initiatives such as reducing car use, supporting the use of public transport and bicycles, and eliminating free parking for employees. However, working outside the office, other activities on the way between home and work, meeting outside the office during office hours work, access to free parking, flexible check-in and check-out times, and distance to work are relevant motivational factors for workers, which have resulted from four knowledge-based companies in the Oslo region of Norway, showing that restrictions on parking could be an effective measure to promote more sustainable commuting mobility [10].

### *4.4. Behavioral Analysis towards More Sustainable Mobility by Workers for Industries*

Behaviors in favor of the environment can be somewhat considered altruistic, for example, giving up the benefits of going to work by car and using the bus for the sake of environmental issues. In a study with a group of workers in Canada, it was found that those who felt morally obliged to reduce car use were more aware of the problems caused by its use. Those who used a car to commute to work felt more responsible for the problems and impacts caused by its use. Abrahamse et al. [32] described the theory of planned behavior, assuming that behavior is determined by the intention to perform. In turn, behavioral intentions are determined by attitudes, subjective norms, and perceived behavioral control, where subjective norms refer to social pressure to act or not and also the motivations to comply with them. Therefore, in this sense, a behavioral approach is needed to promote more sustainable modes of transportation, reducing the use of the car in commuting [32].

In a study in Thailand, the behaviors of several groups of users who lived at different distances between their homes and a public transport station were analyzed. It was identified that the cost and travel time are significant variables in the study and it was also seen that people with a single car per family were the most resistant to change behavior towards a modal shift [49].

Gender differences between men and women play different roles in mobility. Women tend to travel less alone, over shorter distances, and make more complex trips (shops, schools, health centers, etc.), while men mostly travel between home-work without inter-

ruptions. When there is a car available at home, the mobility of men increases more than that of women in that household. These differences in travel patterns between genders are also visible in other factors that influence mobility such as age, number of children, income, and level of education [40].

Healthy behaviors are influencing factors in choosing active travel modes. When there is no adequate infrastructure for active modes (walking and cycling), it limits the use and represents an impediment to use. On the contrary, when there are good conditions for the use of active modes, it can be seen that there are fewer health problems, especially those related to obesity, and in addition to improving the quality of life and the well-being of those people, therefore with a huge contribution to sustainable mobility [47].

The characteristic of the user is directly related to travel behavior, which consequently reflects on land use and the transportation system. Determinants such as income, education, race, place of work, and family composition influence the choice of housing, which affect the real estate market as well as the transportation system [43].

Travel behavior in urban areas is determined by people's daily activities spatially, as they are organized in the built environment. Other factors influence travel behavior such as gender, age, family structure, and income, causing relevant impacts on the choice of travel modes. Families with children, higher income, and age are preponderant factors for greater use of the car [35].

A better understanding of workers' commuting behavior and knowledge of sustainable measures to encourage switching from car to public transport, cycling, or walking is needed [10].

The urban form defined by density, distribution of residences and workplaces, has been shown to structure travel behaviors, through shorter distances and is ideal for walking or cycling, and also to generate trips with low emissions [32]. The fact that people choose for themselves areas where there is an identity with their attitudes towards transport, shows that the place of residence influences travel behavior. Otherwise, people who had tolerance for shorter distances and mild manners could choose to live in the farthest outskirts of their workplaces, so this does not happen [2].

Many studies prove that modal behavior is determined by punctuality and reliability in a mode of transport. A reliable mode, even on a journey taking longer, will be preferred by the user, rather than a shorter journey [36].

Socioeconomic and behavioral user characteristics have been as important as land use in travel. Diversity in land use and balance between employment/housing, parking availability, accessibility, and distance to transport modes are three main characteristics that influence travelers' behavior on commuting trips [48]. Yet, socioeconomic characteristics influence the complexity of the choice of modes of transport, but other psychosocial characteristics can also influence decisions on modal choice such as habits, attitudes, or affection for driving a car [48].

A survey carried out with passengers using the Light Rail Vehicle in Spain, described the influence of behavioral intentions in choosing the service offered. It was found that fuel prices, parking fees, toll prices, speed limits, taxes, and quality of services are decisive in choosing the mode of transport [50].

The behavior of carpooling users can be influenced by several factors, among the most critical are the lack of privacy and comfort for passengers; not driving your car, and social and cultural differences [32,43,50].

In a study on behavioral incentives for the campus of the Massachusetts Institute of Technology, USA, it was identified that in addition to the changes brought by the incentives, there was a decrease in the use of public transport as the climate warmed up during the spring since bus passengers walk or cycle instead of riding a bus [44].

Reducing car use with a shift to active modes not only provides direct environmental effects in reducing emissions but also indirect effects caused by diseases related to this fuel, showing that sustainable mobility offers improvements in people's health and envi-

ronmental quality in cities [13], as well as in other territories and for other purposes such as commuting for industries.

### *4.5. Main Strategies for Promoting Sustainable Mobility of Workers by Industries*

Sustainable Mobility Plans are planning instruments that present a set of sustainable strategies so that organizations can reduce the impact of trips made by their employees. In general, they include strategies related to the promotion of alternative modes of transport, parking, company vehicles, and working hours, among others, which fall within the set of demand management strategies (TDM—Travel Demand Management) [39].

Mobility plans for industries (workplaces) can have good results in terms of reducing car use with one occupant, being necessary that some important factors such as organizational culture, work in partnership between organizations/companies, and recruitment of qualified personnel for the transport area. Consequently, it contributes to the development and growth of the industry, brings benefits to employees, increased productivity, and better quality of life [25].

Europe is one of the regions that have the most experience in implementing mobility plans for companies. An example of this is the United Kingdom, where a set of incentives and restrictions were created to promote a modal shift in travel to workplaces, which resulted in a reduction in the number of trips during peak hours. Once again, awareness and social involvement of employees, as well as dialogue between companies and their employees, played an important role in this behavioral change. In terms of incentives, it is possible to highlight subsidies for parking exclusively for carpooling (shared rides), the use of public transport, and active modes of transport. On the other hand, the restrictions are focused on reducing and taxing parking offers for employees [39].

Since 2011, Brussels companies have adopted awareness-raising and information measures with the mobility of their employees. These measures include encouraging the use of bicycles, car sharing, and the use of public transport. Among the companies surveyed with more than 100 workers, 81% offer reimbursement for km traveled by bicycle, and 64% are related to reimbursement in the payment of public transport. As restrictive measures, the limit on the number of parking spaces and the reduction in the number of cars in the company's fleet stand out. The flexibility of schedules and telework are also good strategies, but many companies depending on their productive sector are unable to make use of this measure [36].

Transportation Demand Management (TDM) encourages the use of collective modes of transport, preferential parking for carpoolers and bicycle users, as well as the adoption of flexible schedules [7]. It also includes the implementation of measures that influence people's behavior to reduce the number of trips, through incentives that promote changes in travel time, route, mode of transport, destination, frequency, and cost, using incentives to use public transport, carpooling, vanpooling, car-sharing, bicycle use, scooters or even walking [8]. In addition, TDM is also concerned with incentive strategies for workers in a given territory, one of which is IBTDM—Incentive Based Traffic Demand Management, where incentives/rewards are given to those who contribute and participate in actions that promote more sustainable mobility during congestion periods. Monitoring takes place via an application installed on the employee's mobile phone during the home-to-work journey, with this it is possible to assess $CO_2$ emissions avoided and accumulate benefits to be exchanged in local shops and countless others [7].

Car sharing is a palliative alternative when public transport services are deficient or if the company's location is not served by the public transport network. It should also be considered that the dispersion of the location of workers' homes makes the car-sharing operation more difficult [36]. As for the use of carpooling, it is related to the home-work route, i.e., where the driver picks up the co-worker at a predetermined location to proceed together to the workplace, being easier to happen if the members share the same points of origin, high levels of confidence and work shift schedules can be reconciled [7,50]. However, there is also a privacy concern, an aversion to being around a stranger, as well as per-

sonal safety that could jeopardize the success of this type of solution. These issues about the use of shared cars were analyzed in a survey with a group of workers from Austin, USA, showing that even with lower service fares a growing number of individual trips was found instead of shared trips [45].

A new concept that redefines transport markets with flexible, efficient, targeted, and user-customized services is called Mobility as a Service (MaaS). This allows the choice of the most suitable mode for each trip, depending on the existing transport options and the recognition of customer preferences, using the real transport network when requesting the trip, functioning as a one-stop shop for mobility services. Finland was a pioneer in the commercialization of mobility plans structured by the MaaS concept, through a trip planning application via monthly prepayment or according to use [41]. MaaS allows users an impartial and independent choice of travel modes, to make the best choices, with the best prices, and the least polluting transport [34,41,46]. MaaS also provides algorithm-based, personalized, and individual mobility solutions through a single application. The traveler can choose multimodal travel chains. However, the traveler must manage the travel chain alone in an integrated way [39].

Even though MaaS is not a measure aimed exclusively at promoting more sustainable mobility, it intends to contribute to that effect and could be seen as an alternative to increasing the offer of public passenger transport services that companies/industries can use. In 2018, companies such as Uber and Lyft transported around 3.2 billion passengers, approaching the number of passengers on the urban bus and train systems. The number of passengers has grown, especially among young professionals with higher levels of education, and in 2019 around 70% of graduates from urban colleges used services offered by these companies [45].

In Table 2 a summary of the main measures found for workers' behavioral or modal change towards sustainable mobility have been identified and listed.

**Table 2.** Measures used by the authors.

| Measures Used for Workers' Sustainable Mobility | Authors | Countries |
|---|---|---|
| Parking management (charging, reduction of parking spaces) | [25,35,39,42,48,49] | UK, Belgium, Portugal, Germany |
| Promotion and incentives through subsidies for carpooling, public transport, and cycling; Parking restrictions | [8,9,13,15,25,34,39,50] | UK, Belgium, Sweden, Lithuania |
| Flexible schedules and teleworking | [1,25,39] | Belgium, Costa Rica, El Salvador, Colombia |
| TDM and MaaS | [1,5–7,34,37,39,41,43] | UK, Finland |
| Companies located near public transport infrastructure | [1,10,25,27,36–38,42,49] | Belgium, USA, Thailand |
| Restriction to one car per household | [49] | Poland |
| Healthy work routines and lifestyles of employees | [8,32,36,39,40,47,49,50] | USA |
| Carpooling | [25,39,47,50] | Sweden |

## 5. Discussion

This article provides a state-of-the-art review of the topic of commuting behavior with an approach to workers of industrial companies. Based on the selection of the articles studied, it is important to highlight that the use of cars in commuting is still high [8,36,39,48], monetary incentives [10,35,44] for those employees who reduce the use of cars to work and parking fees [35,36,39,48], with a reduction in the number of space at the destination (companies) [35,36,39] can be seen as a source of success for a behavioral and modal change to more sustainable modes of transport.

This review points to evidence that commuting is not only related to the home-work-home route but also to intermediate movements, which are often not taken into account in workers' mobility to companies. As workers live in communities with their families, other intermediate movements such as shopping or going to the gym appear routinely in

the commute to work, perhaps not on a constant daily scale, but with a certain regularity and repetitiveness [29,37,40].

Actions for modal change to more sustainable mobility during their commuting trips were identified in the literature review and need to be continually updated so that other companies can see examples of good practices to study and evaluate the possibility of its implementation in their specific industrial contexts. We highlight the important role of companies in promoting and stimulating behavioral changes in their employees towards the use of more sustainable modes of transportation [8,29,36,39], such as collective public transport and other soft modes. Companies can not control the way employees travel to work, however, since these are important traffic generators they must be considered important players in mobility management to achieve the goal of more sustainable mobility [8,15]. However, companies must develop research about their employees' mobility to identify which means of transportation they use and whether they would opt for a more sustainable or healthier mode [8,36,39].

In some territorial contexts with low demand for public transport, outside the peak hours (e.g., entry and exit of working shifts), it is difficult to manage this service due to the variability in operating costs and to ensure the inherent quality of the supply to the expected demand, especially in the entry and exit times of the shifts companies [44].

In this review, it was possible to show that a large number of researched works were related to case studies, which focused on the analysis of the mobility of groups of workers [6,7,9–11,25,32,37,40,42,44,48] and the stimulation of their behavioral and transportation modal change [6,10,11,13,29]. In this context, a sustainable mobility plan for industrial companies can be seen as a major strategy to help encourage behavioral change in workers by industries, which can present good results in reducing the use of cars for commuting purposes to companies [1,6,8,13,15,37,39].

This is followed by sharing cars or carpooling among employees, which reduces the percentage of cars in company parks [7,8,36,39,50] the TDM digital demand control platforms [1,6,8,39], which encourages collective and shared modes, and also MaaS (Mobility as a Service) [6,34,41], which presents a personalized and targeted way of using the existing transportation network in real-time.

It can also be highlighted those employees with healthy daily behaviors, along with a good walking and cycling infrastructure between home and work, encourage the use of the respective soft modes [47].

Lastly, it is important to highlight that there are some limitations in the approach to some subjects related to the scope of this review, namely more research works close to workers' mobility to companies. Therefore, there is a need for industrial companies to promote more studies about the implementation of new stimulus strategies for workers' modal change, which can be used as future examples from other companies to improve the quality of life of their employees, and in an overall manner to promote more sustainable and healthy citizens and communities.

## 6. Conclusions

Governments, as well as industries, must understand the behavior of their inhabitants/workers so that, in an engaged and joint way, they provide a more sustainable mobility for all.

The importance of public policies in land use planning, separating industrial zones from residential ones, has positive and negative points for both sides. For residents of residential areas far from industrial areas, there are positive points such as: they have better environmental quality with regard to air and noise pollution, and a better level of safety for pedestrians due to less intense traffic. On the negative side, the distance between home and work, often without public transport services, leads to greater use of the car when traveling, increasing transport costs and social inequality. In the industrial areas, on the positive side, there are better infrastructure conditions for the implantation of industries, these areas, located further away from urban centers, close to the main access roads, provide the

best production flow. However, there may be a lack of public transport service in these areas, making access from home to work difficult, and also making it difficult to recruit new workers.

Regulations help industries to encourage more sustainable ways for workers, making employers mediators in the change process. This dialogue between public policies and industries must exist for promotion to occur in the form of subsidies, public transport passes at affordable prices, greater use and popularization of carpooling, as already happens in many European countries. In Belgium, for example, subsidies are agreed between workers and employers.

From this study, it can be concluded that there is still a great predominance of the car in commuting between home and work, due to the distance between households and industrial companies. Companies can play an important role in stimulating a modal shift towards more sustainable modes through actions and measures directly applied in their facilities and workers that can foster and facilitate this necessary change to fight current mobility externalities of the existing commuting mobility patterns of company employees.

On the other hand, employees must also be involved in the modal change process, namely in the planning and designing of the proposals, so that transitions to more sustainable mobility can occur. Mainly because many measures will focus on greater conditioning of the use of the car, which has dominated the current mobility patterns of this type of mobility, thus anticipating a strong contestation on the part of the workers. It must be emphasized that a vast majority of authors describe that parking, both at home and at work, is a strong influencer on modal change, either by meeting the number of parking spaces or stipulating a charge for its use, which among other measures could be very unpopular to workers.

It can be seen that if the public transport service is deficient, or are not reliable to the users, it will provide a strong incentive to use the car. Consequently, workers will look for safety and punctuality in the car for their home-work trips. Therefore, a more sustainable car can not be put aside, such as carpooling and carsharing with more efficient and nonpolluting cars, especially for companies located in low-density territories.

Some measures that have been shown to be positive in helping behavioral changes in workers' mobility may not be so successful for industries. Remote work or flexibility of schedules, for example, cannot be adopted because they compromise the productive processes of the industries, being a weakness in the implementation of actions for the change in the modes of transport.

Finally, the literature shows that in certain territorial contexts, there has been a great commitment to bicycles for commuting between work and home, and this should be an investment mainly for short-distance trips.

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