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LITERATURE REVIEW

Identification of critical success factors for implementing sustainable public lighting management in cities: literature-based applications

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ABSTRACT

Goal: The objective of this study was to conduct an exploratory literature search capable of identifying the critical success factors for the implementation of sustainable public lighting management in cities.

Design / Methodology / Approach: To accomplish this, the chosen method was a systematic literature survey conducted according to the Cochrane protocol, using the Web of Science, Scopus, and Science Direct journal databases.

Results: As a result, the study shows that there is a scarcity of scientific literature published in journals regarding the intersection between sustainable management and public lighting. In addition, it became clear that the main practices carried out in this area occur in European cities.

Limitations of the investigation: VOSviewer software was used to build and visualize the bibliometric networks and only two correlated attributes were identified, which shows a lack of similarity between them and demonstrates a limitation of this study.

Practical applications: As a practical implication, the present study supports public managers in decision-making regarding sustainable public lighting, demonstrating the need to implement projects in this field.

Originality/Value: Although this is an extremely important subject, the search showed few studies published in this field.

Keywords: Street lighting system; Sustainable lighting; Urban street lighting; Resource efficiency; Local energy planning.

1. INTRODUCTION

Public lighting (PL) is an essential service that plays a relevant role in the development, progress, function, safety, socialization, and valuing of cities. In Brazil, providing PL service is a responsibility of the municipal administrations and the service itself is provided by power companies as well as by the municipal administrations. According to the United Nations Development Program (PNUD, 2021), the world population's access to electricity increased by 5% between 2000 and 2013, going from 79.31% to 84.58%.

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According to the Energetic Research Company (EPE, 2020), Brazil's final electricity consumption increased by 1.3% in 2019. The sectors that contributed the most to this increase, in absolute values, were the residential sector, which increased its consumption by 4.8 TWh (+3.5%), followed by the commercial sector, which had an increase of 4.1 TWh (+4.5%), the energy production sector with 1.3 TWh (+4.1%) and the public sector with 0.9 TWh (+2.1%).

According to Ruggieri et al. (2021), the expectation is for the energy consumption demand to increase to approximately 1.72×10^5 TWh (66% of the total) due to the number of "megacities" that will have more than 10 million inhabitants. In a study conducted by Ruggieri et al. (2021), it became clear that the consumption from these cities may impact 81% of the world's resources, out of step with populational growth, considering that in 2050 the urban population is supposed to reach 60% of the world's total population.

The increasing urbanization and consumption in cities started to become clearer in the 1950s, with the massive growth of these territories as well as the management challenges that appeared. This matter was emphasized in the Sustainable Development Goals (SDGs) promoted by the United Nations (UN) – 2030 Agenda. SDG No. 11, Sustainable Cities and Communities, deals with the issue of how to make cities and human settlements inclusive, safe, resilient, and sustainable (IPEA, 2011).

Launched in September 2015, the 17 sustainable development goals (SDGs) aim to balance the main factors of urban development. These goals concentrate on long-term benefits and cover various dimensions of city sustainability and intelligence, all the while contemplating a broad framework of challenges around the world (Kutty et al., 2020).

According to Ruggieri et al. (2021), smart cities are frequently perceived as ideal urban environments in their different dimensions, such as: economy, education, energy usage, and environmental agenda. Furthermore, these aspects must be proactively managed. Currently, one of the strategic goals for smart cities is sustainability (Pilipczuk, 2020). In addition to the technical and social skills developed in the training provided by the learning factories, several authors reinforce the importance of discussing the impact of Industry 4.0 on business models and other related concepts such as sustainability, CSR, lean, and others (Cazeri,2022).

Considering society's growing preoccupation with environmental matters and sustainable development, an improvement in Public Lighting energy efficiency is important because PL is essential to the safety and quality of life in urban centers. The PL sector acts as a tool of citizenship because it contributes to citizen safety, prevents crimes, beautifies urban areas, highlights monuments of artistic value, buildings, and landscapes, illuminates pathways, and allows citizens to better enjoy leisure areas (Dambiski, 2007).

Considering this, the present study aims to pursue answers to the following research question: according to the literature, which are the critical success factors that lead some cities to implement sustainable management in Public Lighting? Thus, this article's objective is to conduct an exploratory search in the literature capable of identifying the critical success factors for implementing sustainable PL management in cities.

To fulfill the proposed objective, a systematic survey of the literature was conducted regarding the public administration's sustainable management of lighting services on the Web of Science, Scopus, and Science Direct databases.

Regarding its structure, the present work is divided into four sections. This introductory section contained the context in which this study is inserted, as well as its main motivations and objectives. The second section describes the research methodology. In the third section, the results obtained from the searches on the Web of Science, Scopus, and Science Direct databases are analyzed and discussed. The fourth and final section presents this article's conclusions, highlighting the importance and the contributions of the analyses conducted herein.

2. METHODOLOGY

The systematic literature review is a procedure capable of mapping studies that were previously conducted by other researchers, describing the process of scientific article selection, the inclusion and exclusion criteria for said articles and the process for analyzing each one (Galvão and Ricarte, 2019).

The Cochrane Protocol (CRD, 2009) was applied to support the present study. The literature search was conducted through the CAPES Periodical Portal between March 1st and April 30th, 2021, through the multidisciplinary ISI Web of Science (Thomson Reuters Scientific), Scopus, and Science Direct databases.

According to Higgins and Green (2011), a clearly defined and directed review begins with a question that is related to the research problem presented in this article's introduction: Which are the critical success factors found in scientific literature regarding sustainable management in Public Lighting (PL)?

The research question was based on the PICO acronym, which directs the structuring of search limits and guidelines (Petticrew and Roberts, 2006; Higgins and Green, 2011), besides highlighting the keywords stemming from the research problem, as shown in Table 1.

Table 1 – Search base structuring according to the PICO acronym

Acronym	Meaning	Definition / Application	Keywords
P	Population	The study's defined target population	cities, municipalities, territories,
I	Intervention	The intervention to be observed in the defined population. In this case, the means to the ends are what will be observed.	sustainable public management, sustainable management,
C	Comparison	Used in health-related fields to compare clinical protocols. In this case, it is not applicable.	Not applicable
O	Outcome	The outcomes expected from the intervention in the defined population.	street lighting, street lighting system, sustainable lighting, urban street lighting, resource efficiency, local energy planning

Source: Adapted from Higgins and Green (2011)

For the advanced search, the research string (TS) was built according to the PICO acronym guidelines (Table 2) with the Boolean connectors OR and AND. The sintax used in the search was chosen by the ISI Web of Science database and applied in the search conducted on Scopus. The search string was modified for use in Science Direct because that particular database had limits on the number of characters used in the search and the search had to be split, as follows: (city OR municipality OR territory) AND ("sustainable management") AND (“street lighting” OR “sustainable lighting”).

Table 2 – Search base structuring according to the PICO Acronym I

Construction of the search string (TS) for an advanced search on the ISI Web of Science database based on the PICO acronym				
P	**Boolean connector**	**I**	**Boolean connector**	**O**
((cit* OR municipalit* OR territori*)	AND	(“sustainable public manag*” OR “sustainable manag*”)	AND	(“street lighting” OR “street lighting system” OR “sustainable lighting” OR “urban street lighting” OR “resource efficiency” OR “local energy planning”))
TS=((cit* OR municipalit* OR territori*) AND (“sustainable public manag*” OR “sustainable manag*”) AND (“street lighting” OR “street lighting system” OR “sustainable lighting” OR “urban street lighting” OR “resource efficiency” OR “local energy planning”))				

The triage process for the works includes the gradual application of inclusion criteria (CRD, 2009) considering different perspectives in the ISI Web of Science, Scopus and Science Direct databases. The first criterion that was chosen was language. The second chosen method had to do with document type, which was restricted to articles and reviews.

After obtaining the first articles, a triage of titles and abstracts was conducted. The last recommended eligibility criterion is the triage of the full texts selected up to this stage (CRD, 2009; Higgins and Green, 2011). It is important to note that no time and category limits were established to determine eligibility in the ISI Web of Science, Scopus, and Science Direct databases.

3. RESULT ANALYSIS AND DISCUSSION

3.1 Results and analyses stemming from the systematic literature survey

A new refinement process involved selecting the abstracts. The articles' abstracts were read

so that the triage could lead to the selection of those works that had the most to do with this study's object. Despite there being many articles pertaining to the matters of sustainable cities, sustainable development, energy, use of resources and efficiency, few of them were directly related to the scope of this study.

As a final triage stage, the documents were read in their entirety. At this moment, the articles with the most pertinence to the study's research topic were identified. This stage aimed to categorize the groups of studies in which it was possible to identify critical success factors that led some cities to implement sustainable management procedures in their public lighting services.

The results obtained from the databases included in the search and the filters that were used can be visualized in Table 3.

Table 3 – Selection Stages and Search Results

Selection Stages			
Database	**Web of Science**	**Scopus**	**Science Direct**
Initial Results from databases	48	29	42
Filter 1 - Type of document	Article; Review	-	Article; Review
Filter 2 - Language	English, Spanish and Portuguese	English	-
Document total	37	19	32
Filter 3 – Selection based on Titles	12	12	14
Filter 4 – Selection based on Abstracts	7	6	10
Filter 5 – Selection based on diagonal reading	4	6	2
Filter 6 – Selection based on full reading	4	4	1
Final document total	4	4	1
Documents selected after triage	9		

Source: The authors themselves.

As shown in Table 3, the consolidation of the Web of Science, Scopus, and Science Direct databases resulted in a total of 9 articles focusing on this study's proposed subject, with the aim to answer the aforementioned research question.

After this stage, the VOSviewer (VOSviewer – Visualizing scientific landscapes) was used to visualize the attributes to be analyzed according to their similarities. This was done with the documents' titles and abstracts and the results are shown in Figure 1.

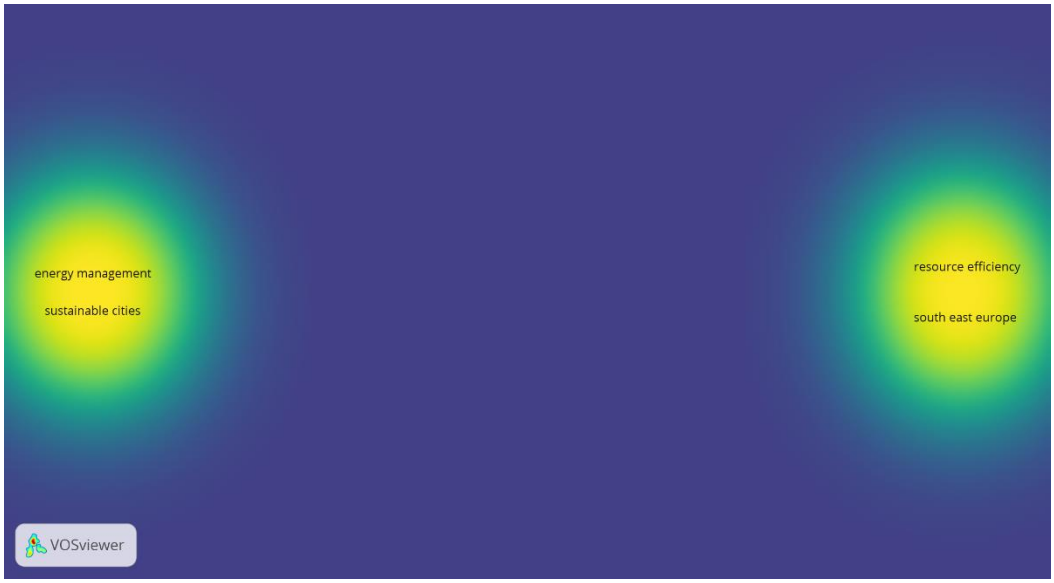

Figure 1 – Identification of Similarities
Source: The authors themselves

With the software, it was possible to identify only two related characteristics and the lack of similarity between them became apparent.

In order to rank the Constructs' importance weight further work supported in decision-making methods. This can evidence the importance of the knowledge to different organizations, culture and product and/or service (Cavaco and Muniz Junior, 2020).

The proposed analysis touches upon the authors' main statements and the years of their publications that are related to the subject in question. Most of the selected journals are from the energy research field (Emc Review - Časopis Za Ekonomiju; Economic Research-Ekonomska Istrazivanja; IEEE Transactions on Automation Science and Engineering; Energy Policy; Renewable and Sustainable Energy Reviews; Future Generation Computer Systems; EEA - Electrotehnica, Electronica, Automatica; Energies; A Renewable and Sustainable Energy Review).

The article written by Salvia et al. (2019) demonstrates that studies pertaining to sustainable management in public lighting are scarce. The authors reveal that publications in this field tend to be more related to technical issues within the energy sector than to sustainable management. However, they mention that public lighting has much to contribute to the search for efficiency and sustainability and that it is a sector that requires much more attention from managers. The study investigated the main practices used worldwide regarding energy and efficiency in public lighting. One of the practices they identified was the support for developing alternative energy sources (renewable) to harness solar and/or wind power. In all the identified practices, the authors mentioned technological and environmental aspects and regulators, with the intent to save energy, reduce costs and increase the lighting system's efficiency. As for the financial and political aspects, they tend to be effective in this type of energy project if they are supported by municipal, state, or even national energy plans, which subsidize the implementation of sustainable public lighting projects.

Although it does not specifically touch upon this matter, the study by Díaz-Díaz et al. (2017) shows the results of a case study in public lighting, conducted in the city of Santander, Spain. The authors presented data and information pertaining to the implementation of a more efficient system which uses LED technology. Furthermore, a practice adopted in that city is to adapt the light intensity to the lamp's location. The authors stated that a company won the public selection process, earning the right to manage the public lighting system for 15 years and will receive a total of 34.3 million euros during this period. Thus, the projected 65% economy will be shared, with 60% going to the company and 40% going to the City Council. The project's initial investment was 11 million euros, used to replace the 22,700 existing streetlights. The new system aims to reduce CO2 emissions by 2.4 million kilograms per year.

The article written by Gago-Calderón et al. (2018) shows relevant information pertaining to the efficiency of using LED technology. According to the authors, estimates show the transition to LED lighting may reduce electricity consumption in public lighting by up to 50%. They showed the data from an LED test conducted in 106 cases from 17 European countries, which demonstrated an average reduction of 55% in energy consumption when compared to the

original system. They stated that the high cost of public lighting is an incentive for cities to lead in the use of more efficient technologies. The authors also mentioned the 2010 Covenant of Mayors, in which the signatories from 4,400 cities in the European Union signed a deal committing to implement sustainable energy action plans. The authors concluded that one of the main objectives of LED manufacturers is to maximize their products' energy efficiency.

Dejan Milenković and Vladimir Đurić (2020) highlight the application of the "Value for Money" (VfM) method in PPPs related to public lighting in the Republic of Serbia. Upon applying the Public Sector Cost Comparison (PSC) to the VfM, they demonstrated the method for cost calculation, as well as the level of savings that was reached. The main indicator of financial efficiency is the financial net present value of the project's expenses – NPV. On analyzing the basic capital costs and risks, the basic operation costs and risks, as well as the basic financing costs and risks, they concluded that in all of the 11 projects that were finalized based on a public contract in the last two years, significant savings were obtained for the city/municipality on one hand and, on the other hand, the public lighting service quality level for the citizens improved.

In their article, Wadim Strielkowski et al. (2020) researched the determinant factors of economic efficiency and evaluated the pre-requisites for energetic safety in European and non-European smart cities. The results of the empirical model that was investigated showed the urgent need to replace the old lighting system for a new one (solar-powered LED lamps). The results seem to be fully justified from the economic perspective. The basis for this conclusion resides in important indicators, such as liquid savings, the project payback period in an interval of 3-4 years, as well as the energy savings (2594755.8 kW). These indicators demonstrated the efficiency, viability, importance, and attractiveness of investing in this project. However, in the context of the study and its specific focus, it seems that LED lighting systems may result in growing economic gains and contribute to the sustainable development of urban centers, which makes the systems a good element in the worldwide strategy for sustainable economic development and its efficiency.

In their study, Raffaele Carli and Mariagrazia Dotoli (2020) propose a decision-making process that helps the city's energy manager determine the best plan for retrofitting an existing public lighting system in an ample urban area in the city of Bari (Italy). The proposed decision model aimed to simultaneously stimulate the reduction in energy consumption and the obtention of a good retrofit allocation among the public lighting subsystems, efficiently using the available budget. The resulting optimization problem is formulated as a quadratic knapsack problem. On one hand, this article fills an existing literature gap, in which there is a lack of investigation on efficient computational decision models for selecting energetic retrofit actions for public lighting systems in an ample urban area. On the other hand, applying the proposed method to a real case study proves that it is a practical decision support tool for the city's energy system, to improve the energetic performance of the public lighting system, simultaneously guaranteeing an optimal distribution of retrofit interventions among the subsystems.

3.2Theoretical correlations between sustainability and public lighting

Since the 1987 Brundtland Report, the concept of sustainable development as well as the concept of sustainable cities have led to various studies and definitions. According to the UN (UN, 1987), sustainable development is that which satisfies the needs of the present without compromising the capability of future generations to satisfy their own needs. It is possible to state that a sustainable city uses renewable resources at a lower rate than it generates energy, and also uses non-renewable resources at a lower rate than that of renewable alternative development, simultaneously reducing the impact on the environment (Goldman and Gorham, 2006).

For Sodiq et al. (2019), however, a sustainable city is based on knowledge, and each of its constitutive elements must be efficient. Energetic efficiency is a pillar of sustainability, which must be used in a sustainable city to avoid wasting energy.

Sustainable development became more important after the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992. At the time, the Agenda 21 document, which proposed sustainability guidelines for territorial management, was approved (BOARETO, 2008).

In 2015, the Agenda 2030 for Sustainable Development Goals (SDGs) was created by heads of State who represented various countries and civil society (PNUD, n.d.). The agenda, which was promoted by the United Nations, appeared as a global consensus and a set of governance guidelines made to fill the sustainability gap, taking on the ecological, social and economic challenges faced by society (Castro et al., 2021).

Sustainability is an increasingly debated subject matter among the economic sectors, including that of electricity, due to the increase in energy consumption (Salvia et al., 2016).

The energy sector is very broad, and includes electrical energy consumption, fuels, and renewable sources, among others. Electrical power itself has many uses, such as residential, industrial, commercial, rural, or public lighting (Salvia et al., 2016).

According to Molina-Moreno et al. (2018), the impact of public lighting on energy consumption, financial costs, on the use of raw materials and on the environment has been a source of much concern. The increase in energy needed to satisfy the growing consumption in cities around the world has led researchers to look for alternatives to traditional fossil fuels. However, there is not much implementation of these alternatives in public lighting (Molina-Moreno et al., 2018).

3.3 Survey of sustainable applications in public lighting on an international scale

Public lighting is an extremely important feature in both urban and rural areas, since it increases people's safety on the streets and is a sector that consumes a significant amount of power (Aziz et al., 2020). In some countries, such as Argelia, most of the public lighting system uses inefficient equipment powered by the electrical network or by diesel generators. This requires a search for alternatives to reduce power consumption in this sector.

The growing interest in efficient energy and environmental sustainability led to the definition of more efficient installations in the public lighting sector (Molina-Moreno et al., 2018). Researchers such as Lin and Huang (2009) touched upon the energetic optimization and retrofitting of existing public lighting systems while Pintér et al. (2018) investigated the economic benefits of investing in photovoltaic and LED technologies in the public lighting system of Pusztacsalád, Hungary.

According to Salvia et al. (2015), administrating resources efficiently requires the involvement of various levels of government, which in turn requires strengthening relations between the interested parties to promote cooperation with public and private institutions, the scientific community, and with citizens. The authorities must develop and implement policies to improve quality of life in urban areas while simultaneously guaranteeing a reduction in resource extraction, energy consumption and waste from generation (Di Leo & Salvia, 2017).

On the other hand, resource efficiency is a common challenge for cities. Qualification, technology, and knowledge support are vital for facing the challenges posed by resource efficiency in cities in an integrated manner (Di Leo & Salvia, 2017).

From this standpoint, Dall'O' et al. (2013), developed a broad and effective tool to help public administrators make choices for programming Sustainable Energy Action Plans. During the project, according to the authors, the cities and their employees acquired technical competence to use different decision-making tools for energetic and waste management planning.

Local and regional governments, businesses of all sizes, institutions of knowledge (universities or private consultancies) and civil society, which includes local organizations and individual citizens, are essential spheres for executing local and regional sustainable resource action plans, such as sustainable energy action plans (Salvia et al., 2015).

However, according to Farzaneh et al. (2016), in the context of urban energy systems, the local government has the legitimacy to regulate the energy systems in the cities. For the author, the success of any urban climate action plan that aims to reduce or attenuate energy usage depends on the ties between the local power suppliers and the municipal government.

Salvia et al. (2015) state that cities answer for around 80% of global greenhouse gas emissions, since urban centers concentrate most of the activities related to the production and consumption of goods and services and more than two thirds of the European population lives in cities. However, the solution is also supported by movements tied to the cities, as shown in Table 4.

Table 4 – Climate Movements for Cities

Climate Movements for Cities	What are they?	What do they do?	Sources
ICLEI - Local Governments for Sustainability	Global network of more than 1,750 local and regional governments committed to sustainable urban development.	Involves more than 100 countries and influences sustainability policies, supporting local actions for low emission development that is	(ICLEI, n.d.)

		naturally based, equitable, resilient, and circular.	
The Covenant of Mayors	Movement of local governments committing to go beyond their own national climate and energy objectives.	The Covenant of Mayors touches upon three main issues: mitigating climate changes, adapting to climate change's adverse effects, and universal access to clean, safe and accessible energy.	(Covenant of Mayors et al., 1987)
Carbon Climate Registry (cCR) by ICLEI	Unified Reporting System for subnational climate actions	Supports cities, villages and regions in the fight against climate change to create transparency, responsibility, and credibility. Helps many important initiatives to strengthen local and subnational climate actions.	(Registry, n.d.)
Energy Cities – The European Association of Cities in Energy Transition	Network of 1000 local governments from 30 countries.	Transforms European governance and judicial structures to allow cities to fully play their roles in the energetic transition.	(Cities, n.d.)

Source: The authors themselves.

According to Salvia et al. (2015), international experiments showed that when the interested parties are engaged, the strategy designs are much better applied. The exchanges of information, ideas and knowledge brings about a democratic and transparent planning process. This increases people's willingness to cooperate to implement the strategy from these action plans. Some municipal actors are essential at this moment, such as the mayor, as well as other decision-makers, and local media, which can be very useful (SALVIA et al., 2015).

Some countries created relevant activities and projects that were co-financed by Europe. Furthermore, they developed a methodology to support the creation of energy plans for local communities, implementing them in rural communities in four countries: Austria, Croatia, Greece, and Portugal (Di Leo & Salvia, 2017).

3.4 Practical applications of sustainable management in public lighting

The RE-SEEties project – Energy Prediction Tool, financed by a program from Southeast Europe – aims to contribute to the challenges of resource efficiency and waste production and disposal. This project also stimulates potential changes in consumption patterns and proposes alternatives for the formulation of policies that can support the fulfillment of resource efficiency goals (Salvia et al., 2015).

Southeast Europe's Research and Cities center has been conducting a unique international cooperation experiment through RE-SEEties projects (Salvia et al., 2015). The tool is in use in countries such as Croatia, the Republic of North Macedonia, Greece, Hungary, Romania, Slovakia, and Slovenia, and has already been used by cities such as: Nitra (SK), Miercurea Ciuc (RO), Ptuj (SL), Egaleo (GR), Ivanić-Grad (HR), Budapest (HU), and Skopje (MK) (REE-SEETIES, n.d.). An innovative aspect of RE-SEEties is its broad vision of urban energy systems, acting upon the challenges of circular economy in this region of Europe and proposing an integrated, transnational approach for the promotion of renewable energy sources and energy efficiency (Reuter et al., 2019).

According to Salvia et al. (2015), the RE-SEEties project developed partnerships with the cities to create a set of behavior-changing tools, as well as to conduct local educational campaigns. With the common name "Change your behavior", the educational campaign was conducted between April and September of 2014 and directed towards the eight cities participating in the project, including a wide array of stakeholders, such as: citizens, local governments and public service companies, small and medium businesses and academics of all ages (Salvia et al., 2015).

Furthermore, the authors demonstrated that the campaigns were extremely successful, reaching more than 650 thousand people in Southeastern Europe, educating the local communities and citizens on the efficient use of resources, and overcoming the initial goal of

reaching 12 thousand people. School contests were held, as well as exhibits, kindergarten workshops, local energy days, and conferences. All cities used their local media in the form of televised interviews, articles, and commercials to project the campaign on a large scale.

The previously mentioned authors used the experiments that were conducted in the context of behavior modification to affirm that the local governments must take the initiative and play a fundamental role as enablers of change, especially in terms of education and facilitating community and business actions alongside the interested parties. In addition, it was clear that the citizens should also be involved in the formulation of local energy and waste policies, in an open dialog with the municipal administration.

Finally, project RE-SEEties revealed that citizen participation is possible, by establishing platforms for local interested parties, organizing peer review and research workshops for the inhabitants regarding waste and energetic infrastructure in the future. Furthermore, this cooperative effort perfected the strategic planning and the decision-making process, while advancing the capability of developing, implementing, and monitoring resource efficiency (Salvia et al., 2015).

This project presents discussions and lessons that should serve as an example for other countries, proving that behavior changes and politics can encourage public authorities, companies, and citizens to be more sustainable, considering interrelated matters that cover the policy-making process, financing local resource efficiency investments, best practices, tools that support decision-making and evaluation methods (Salvia et al., 2015).

The increase in power consumption around the world has led researchers to seek alternatives to classic fossil fuels. In this context, Molina-Moreno et al. (2018) emphasized in their study the urgent need for a more sustainable public lighting and sought to identify whether it was possible to increase energetic efficiency in rural populations from the province of Jaén by using biomass as a technological-energetic nutrient in the context of a circular economy (CE) as a source of power for public lighting needs. To this end, an analysis was conducted of the agro-industrial district of "La Loma", as well as in Baeza, a city located in the south of Spain with a relevant production of olive oil. The results highlighted the main advantages brought by the proposal: (1) Viability of changing traditional HPS lighting to LED without a high investment or credits, since the change pays for itself thanks to the exceeding energy; (2) The valuation of agricultural waste generated financial revenue and reduced the massive migration from the countryside to the cities; (3) The CO2 emissions will be considerably reduced, helping the countries to follow international protocols and requirements.

Within this context, Aziz et al. (2020) conducted a technical and economic viability analysis of various public lighting system configurations based on a Homer software simulation and selected a small village located in Brabra M'sila, Argelia, to use as a case study. The reason for this study has to do with the country's high energy consumption, with 80% of each city's total power use being funneled into public lighting, making it essential to reduce consumption in that sector. Based on the optimization results that were obtained, a public lighting system using LED technology configured to use solar and network power was shown to be more economical compared to the system using HPS lamps, reducing power consumption, the net present value (NPV), and the cost of electrical power by 30%, 51%, and 63.45%, respectively.

Saving energy in public lighting generally consists of replacing existing lamps for new and efficient ones. In this context, the city of Aigaleo (Greece) planned to replace all its existing lamps with new ones by 2020, in accordance with the technological evolution of lamps, reflectors, renewable energy integration and smart adjustments for public lighting intensity (Di Leo & Salvia, 2017).

The energy management agency in Miercurea Ciuc (Romania) financed a viability study with the intention to replace its public lighting with a low-voltage system with smart measurement of lighting needs, thus permitting a considerable reduction of electricity consumption (Di Leo & Salvia, 2017).

In a bid to make public lighting more efficient, the city of Nitra (Slovakia) planned the installation of control systems to reduce the lamps' luminosity, modernizing measurements and replacing some of the existing lamps with newer, more efficient ones, as well as replacing the electrical equipment (Di Leo and Salvia, 2017).

The application of these actions is directly related to the sector's sustainability. However, this term is quite broad since sustainability can be defined in countless manners. According to Mikhailova (2004), the logical meaning of sustainability is the capability to sustain oneself, to maintain oneself. Thus, a sustainable activity is one that can be maintained forever. Considering this, according to the author, a sustainable society is that which does not put the environment's elements at risk. According to Salvia et al. (2016), sustainability in the electric sector thus consists in guaranteeing power distribution for the whole population, using more

renewable sources in order to not affect the environment and encouraging energy efficiency, doing more, but consuming less, which is related to energy savings generally speaking.

4. CONCLUSION

This article aimed to present the critical success factors that lead some cities to implement sustainable management in Public Lighting, as found in the literature. In light of the searches that were conducted, it was possible to verify that there are efficiency policies and programs in place for a sustainable management of public lighting, with the most notable one occurring in Europe. The VOSviewer Software identified the existence of only two correlated attributes and the lack of similarity between them. This result and the study's limitations reside in the fact that there is a gap between sustainable management and public lighting. The ties between these subjects constitute an area of knowledge that is currently unexplored.

The use of Light Emitting Diode (LED) technology is currently more present, with the aim to reduce electricity consumption in cities and, thus, increase the population's quality of life regarding the aspects of public lighting.

It is understood that the main purpose of sustainable public lighting must be to protect people and properties, promoting an improvement in quality of life and safety, and generating savings. Thus, the subject involves a relevant contribution to the social, economic, and environmental development of urban centers.

Furthermore, the movements pertaining to climate change in cities, which stem from various social actors, and an increase in the pressure said social actors exert on the cities for them to fulfill climate change goals and comply with international agreements or covenants and protocols encouraged by the UN, may contribute to the need for a better management of sustainability in public lighting systems.

We conclude that sustainable management in public lighting surpasses the three pillars of sustainability. Environmentally, results can be obtained by reducing the consumption of natural resources as well as CO2 emissions. As for the economic aspect, there may be a medium to long-term cost reduction with the implementation of a smarter and more efficient lighting system in the cities. Socially, the conclusion is that this sustainable management is the provision of a better-quality service for the population to enjoy.

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