Smart Cities: A Systematic Mapping on an Academic Basis

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Abstract

Smart Cities belong to a multidisciplinary research area, which does not yet have a formal definition and may have different meanings depending on the context. In view of this, the objective of this work is to map the term "Smart City" in the scientific field. For such, the scientific publications present in Scopus' data base, accessed by the Periodicals portal of the Coordination for the Improvement of Higher Level Personnel (CAPES), were researched. As results, 61,435 publications were found, which after the inclusion criteria, 632 publications remained to be analyzed. China was the country that presented the largest number of publications with a total of 94 documents. The analysis of annual publications showed that there was an increase in the number of publications over the years, especially between 2018 and 2019. The main contributions of this work were the provision of a knowledge base that can be used by both scientists and researchers and developers of the organizations, identifying gaps and opportunities to be explored.

Keywords: Intellectual Property; Smart City; Innovation.

1. Introduction

Smart Cities (SC) is a theme that began in academia and spread to the business environment. It is a term that does not yet have a formal definition, as it depends on the context to make sense [1].

Therefore, an Smart City, in fact, is a group of people with intelligence who form a large cluster of people called the city. According to [2], An Smart City is to put people at the center of everything, and through technologies, especially Information and Communication Technologies (ICT) [3], foster a governance that uses collaborative planning and citizen for the creative, integrated and sustainable development of innovations that favor competitiveness, entrepreneurship, resilience and constant improvement of quality of life.

The objective of Smart Cities is to make better use of resources, increasing the quality of services offered to citizens [1]. According to a report presented by [4], 68% of the world's population will live in urban areas, cities, by 2050.

Thus, given the various definitions and the relevance of the theme Smart Cities, this work aims to map the term "Smart City" in the scientific field. This type of research is, according to [5], a type of systematic review that aims to delineate an area that has a more comprehensive scope and wants to gather, through research questions, as much information as possible about a particular area of knowledge or topic.

The main motivation for this research is to form a knowledge base that offers in a single work resources to support the development of other research and developments in the area of Smart Cities, promoting innovation.

This document is organized as follows. Section 2 presents the methodology used in the research. Section 3 presents the results. Section 4, the threats to validity. Finally, the final considerations are presented in Section 5.

2. Methodology

The Systematic Mapping protocol (MS) defined by [6] was used to conduct this article. The Scientific Mapping (SC) process was applied, as it was a review of original primary works in an international database of peer-reviewed scientific research.

Because it is a subject that covers many areas of research, multidisciplinary. The publications database [7] was selected. This database was defined due to the great relevance of its publications to the scientific community and society [8]. It is also the largest multidisciplinary database of abstracts, citations and full texts of the world's revised scientific literature, covering publications since 1960, with more than 18,500 titles from approximately 5,000 international publishers, with daily updates [7].

For the analysis of the results, the spreadsheet publishing software produced by Microsoft, Microsoft Excel [9] together with the VOS viewer collaboration network software [10] were used.

2.1 Research Questions

The research questions were defined from the mapping objective. In order to situate researchers and those interested in the subject on the relevance and scope of publications on Smart Cities. Thus, the following research questions were created to guide the conduct of this work:

* - Q1 - Which country or territory presents the most publications?
* - Q2 - How are the publications distributed over the years?
* - Q3 - Which research areas have the most publications?
* - Q4 - Which author publishes the most?
* - Q5 - Which institution promotes the most publications?

2.2 Search Strategy

The searches were carried out in January 2020 and the base search process began with conducting pilot searches with the keywords, described in Table 1, through the Periodical Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES) [11]. These pilot searches consisted of a combination of keywords and related synonyms, all in English, due to the characteristics of the searched databases. Only publications made until 2019 were taken into account.

Table 1 **- Keywords used to form the search strategy**

Key Word	Synonym in English
Smart City	*smart city, intelligent city*

Source: Prepared by the authors (2020).

After adaptation through pilot searches, a Search String was defined to conduct the mapping on the defined bases, as shown in Table 2.

Table 2 **- Search string set to search in SCOPUS bases**

(("smart* cit*")   OR   ("smartcit*")   OR   ("intelligent cit*") OR ("intelligentcit*"))

Source: Prepared by the authors (2020).

2.3 Inclusion/Exclusion Criteria

With the string formed, the Inclusion Criteria (IC) were used to determine the relevance of publications in the research bases, the Inclusion Criteria defined for the bases were:

I.   Have one of the key words in the "Title" field of the publication;

II.   Be published as "Open Access";

III.   Be of the type "Article";

IV.   Be in the languages: "Portuguese", "English" or "Spanish".

To be applied in the analysis of the titles, keywords, abstracts and conclusions, the following Exclusion Criteria were defined to ensure the quality of the work:

I.   Duplicate Publications;

II.   Repeated Studies;

III.   Publications that are not available in full;

IV.   Publications that are no longer available in the bases.

With the definition of the Inclusion/Exclusion Criteria a specific string was created for the base and then searches were made in [7]. As will be presented in the next sessions.

3. Results and Discussion

The following section will present the results of the systematic mapping process of publications from the researched bases and a brief analysis.

3.1 General Information

The search string with the search terms was used in the base [7] and returned the quantity of primary works described in Table 3.

Table 3 - *Criteria used and results in the Scopus base*

Inclusion Criteria	Results
All fields (No inclusion criteria)	61.435
Have one of the keywords in the "Title" field of the publication	6.662
Being published as "Open Access"	1.051
Be of the "Article" type	645
Be in the languages: "Portuguese", "English" or "Spanish".	632

Source: Prepared by the authors (2020).

This search resulted in the base specific search string [7], shown in Table 4

Table 4 - **Specific and Quantitative Search String of publications returned at Scopus**

Search string	Publications
TITLE ((("smart* cit*") OR ("smartcit*") OR ("intelligent cit*") OR ("intelligentcit*"))) AND (LIMIT-TO (ACCESSTYPE(OA))) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese"))	632

Source: Prepared by the authors (2020).

A total of 632 publications were returned from the base after using the Inclusion/Exclusion Criteria. The relationship between the key words of the publications can be seen in the heat map, presented in Figure 1, formed by 210 single words divided into 6 clusters. The key words "smart city" in the center and "internet of things", "big data", "human", among others, to the surroundings are highlighted.

Figure 1 - Representation of the collaboration network between the keywords

Source: Prepared by the authors (2020).

3.2 Answers to Research Questions

This section will show the results from the systematic mapping in order to answer the Research Questions of this study.

Q1. Which country or territory has the most publications?

The country or territory that presented the most publications was China with 94 occurrences. Then came Spain with 80 and the United States with 71 publications. Brazil presented a total of 18 publications on the theme Smart Cities. As shown in Figure 2.

Regarding the co-authorship network, presented in Figure 3, it is formed by 14 clusters with a total of 73 single countries or territories interconnected according to the joint participation in publications. The countries that stood out most were China, United States, Spain, United Kingdom, Italy, India and South Korea. The others are represented by cluster center linkages.
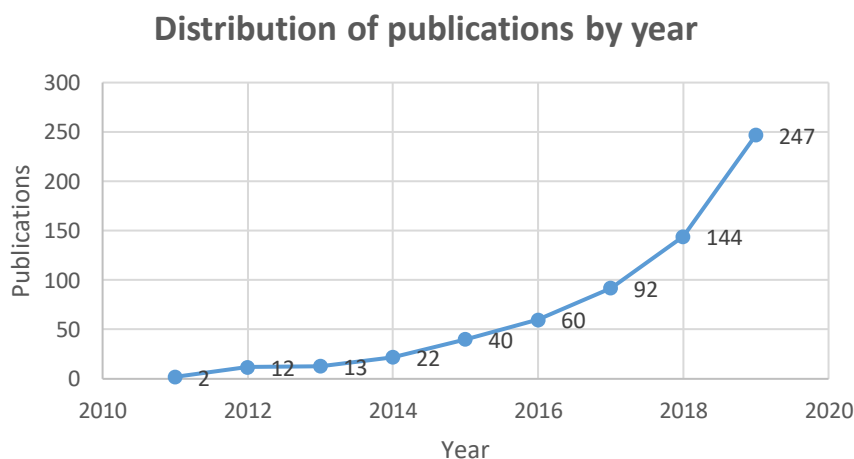
Figure 2 - Distribution of publications by country or territory

Source: Prepared by the authors (2020).
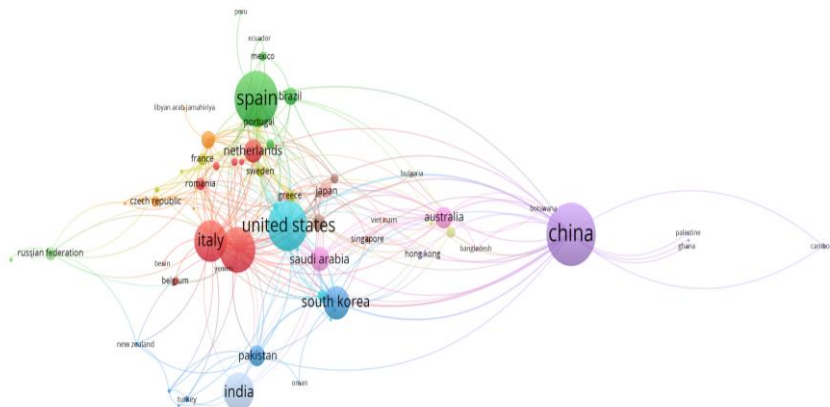
Figure 3 - Representation of the network of collaboration between the countries

Source: Prepared by the authors (2020).

Q2. How is the distribution of publications over the years presented?

Analyzing the publications over time at the base, an increase in the number of works between all years, from 2011 onwards, is highlighted. With a more significant increase of 103 between the years 2018 (144) and 2019 (247). Presented in Figure 4.

Also, the work [1], is the most cited publication over the years, with a total of 2357 citations. As can be seen in Figure 5, which presents the network of collaboration between publications over the years. The network is composed of all works that have had citations over time (310) grouped into 43 clusters.

Figure 4 - Distribution of publications by year

Source: Prepared by the authors (2020).
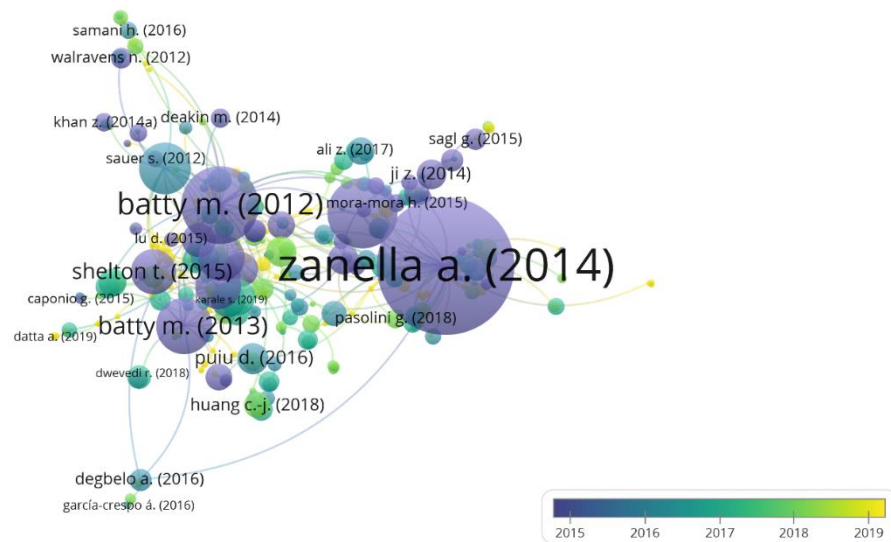
Figure 5 - Representation of the collaborative network of publication citations over the years

Source: Prepared by the authors (2020).

Q3. Which research areas have the most publications?

Regarding the research areas of the works published, in the base [7], the Engineering area stands out with a total of 354 publications, followed by Computer Science with 274, in second place, and in third place the Social Sciences area, with 167. As presented in Figure 6. Such characteristic may be due to the subject being of a multidisciplinary scope, involving several branches of research.
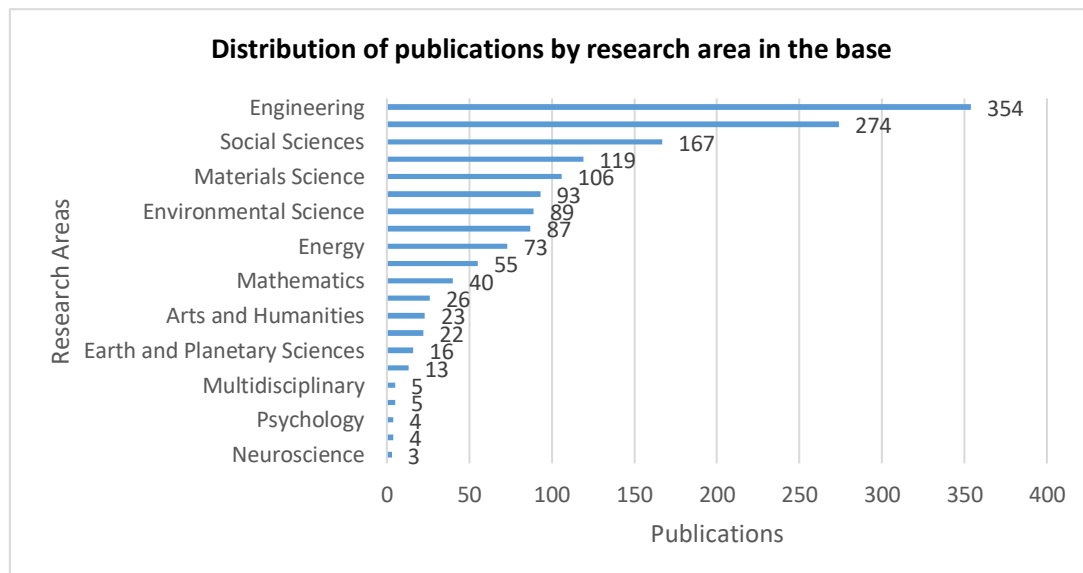
Figure 6 - Distribution of publications by research area in the base

Source: Prepared by the authors (2020).

Q4. Which author publishes the most?

Analyzing the authorship of the publications, the author with the greatest number of publications is "Muñoz, L." with 7 documents. The other authors can be verified in Figure 7.

Also, a network of co-authors is presented in Figure 8, composed of 228 authors forming 22 clusters. The

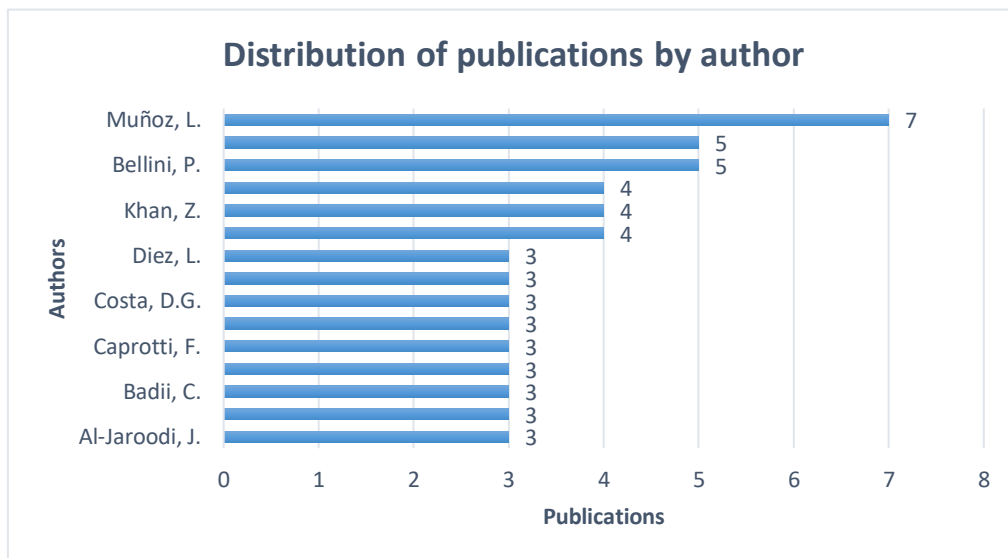authors who most co-publish are "Wu j"., Zhang y., Wang h. Zhang x. , Liu y. Kantarci b.

Figure 7 - Distribution of publications by author
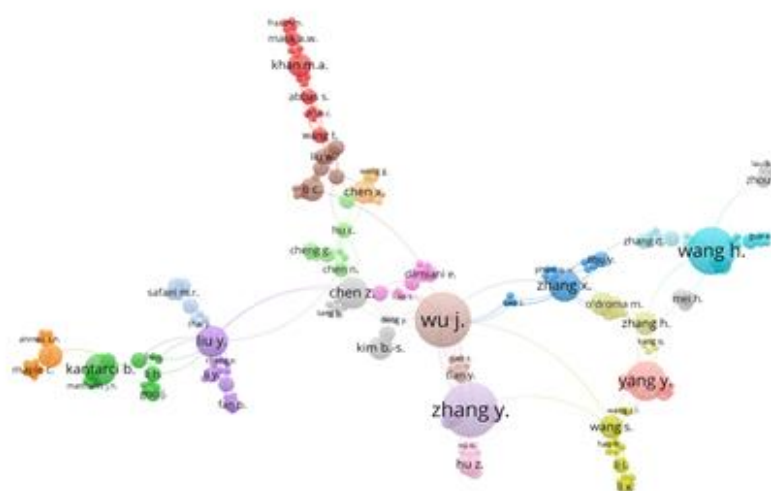
Source: Prepared by the authors (2020).

Figure 8 - Representation of the collaboration network between authors/co-authorships

Source: Prepared by the authors (2020).

Q5. *Which institution promotes the most publications?*

Regarding the analysis of institutions and their publications, "Wuhan University" and "King Saud University" stand out as the institutions with the highest number of published works, with 9 works each. The other main ones can be seen in the graph represented in Figure 9.

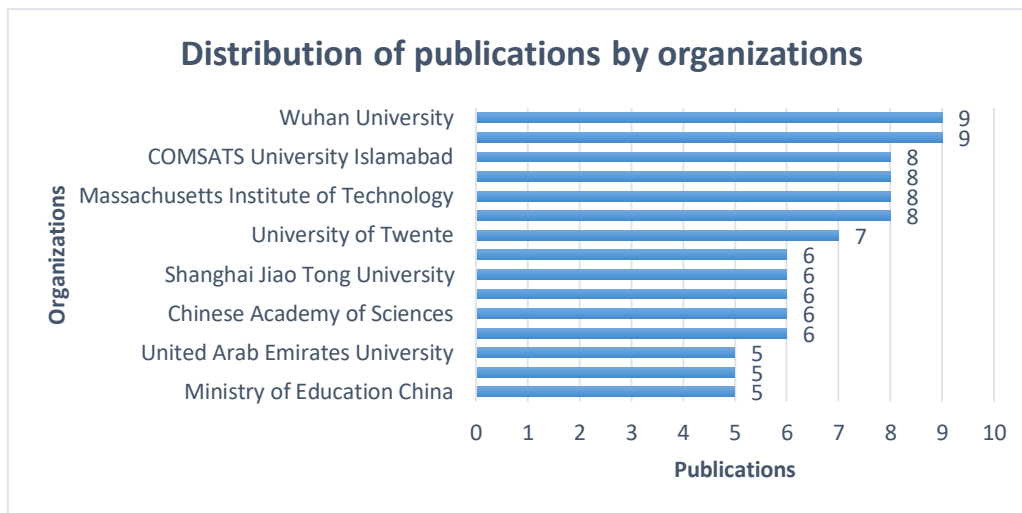**Distribution of publications by organizations**

Figure 9 - Distribution of publications by organizations
Source: Prepared by the authors (2020).

Figure 10 shows the collaborative network between the institutions that have had publications in the database. Only one cluster was formed with 12 institutions that published in co-authorship.
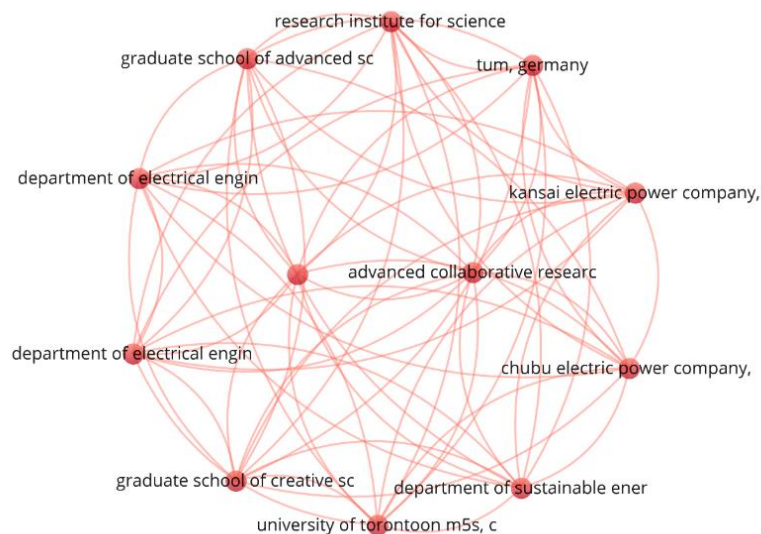

Figure 10 - Distribution of publications by organizations
Source: Prepared by the authors (2020).

4. Threats to Validity

The validation of the Systematic Mapping protocol was carried out by a researcher in the area of Computing who develops research on Smart Cities, however, there was no validation or participation of a group of people in the selection and extraction of data from the works, this being a threat to the validity of this research due to the possible presence of bias.

Another threat is linked to the number of works analyzed in the entirety (632) in a short period of time,

which required great effort and may have caused fatigue in the process.

Regarding the selection of works, only a database using a string was used, which represented the search terms. Soon there may be other works in other bases and that may have other keywords and synonyms of search. To mitigate this threat the string was made according to the main theme and the database has a large number of publications in common with other large databases and this has relevance on multidisciplinary works that is the focus of this search.

5. Final Considerations

The systematic mapping presented in this work identified 632 publications on the theme of Smart Cities, published between 2011 and 2019, presenting a growing number of works that may be an indication of a current and relevant theme that is growing in the interests of the scientific and business communities.

It was also possible to notice that China is the country with the most publications with a total of 94 occurrences and that the "Wuhan University" is the institution that most promotes the works in this area. Brazil presented 18 publications on the subject.

Also, the areas that stood out the most were Engineering, Computer Science and Social Sciences, respectively.

Muñoz, L. was highlighted as the author who published the most on the subject.

The main contributions of this work were:

To map and analyze in a systematic way the scientific researches about Smart Cities, providing an initial knowledge base that can be used by both scientists of the academy and researchers and developers of the organizations. Besides presenting gaps and opportunities that can be explored in future work.

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