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SMART CITY CONCEPT IN THE LIGHT OF THE LITERATURE REVIEW

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ABSTRACT

Nowadays, the transformations of metropolises into smart cities is a crucial factor in improving the living conditions of the inhabitants. The goal of the smart city concept is modern urban management using technical tools that offer state-of-the-art technologies, considering the applicable ecological standards while saving resources and achieving the expected results. The purpose of this article is to identify the areas of research analysed in the international literature in the field of smart cities. The bibliometric analysis was carried out to achieve the purpose. The analysis covered publications on smart cities published in Scopus and Web of Science databases from January 2009 to May 2019. Based on the bibliometric analysis, a bibliometric map was developed using the mapping technique VOS — the visualisation of similarities. Original clusters were created using the VOSviewer software. The bibliometric map visualises the results of the analysis that targeted the word coexistence.

KEY WORDS

smart city, smart city subareas, bibliometric map

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INTRODUCTION

A city appears to be an obvious concept only when it is a secondary subject of research and is used as a relatively obvious context. As soon as it becomes the centre of interests, the focus should be not so much on precise and unambiguous definitions but functional conceptualisations (Matyja, 2017). A contemporary city is perceived as a socio-economic sys-

tem. It is characterised by the complexity of many elements and their interrelations that integrate the city's components so that it can function and develop (Stawasz & Sikora-Fernandez, 2015). Urban development is determined by the constantly increasing migration of people from rural areas to urbanised areas. In 2018, 55% of the global population lived in urban areas. According to forecasts developed by the

Population Division of the United Nations Department of Economic and Social Affairs (UN DESA), in 2050, this share will increase to 68%. The global urban population in 2018 was 4.2 billion. Increasing urbanisation and gradual migration of people from rural to urban areas, combined with the general increase in the global population, means that by 2050, urban areas will accommodate another 2.5 billion people (nearly 90% of this increase will take place in Asia and Africa) (United Nations, 2018). Based on the forecasts, the next few decades should see cities undergoing constant changes, including in their structures. With the expected increase in the number of urban residents around the world, the need is growing for new and innovative ways to manage the complexity of urban life.

Considering the growing importance of cities in the development of many regions and countries, supported each year by the increasing number of smart city initiatives, the authors conducted a bibliographic analysis of the existing publications in this area, collected in Scopus and Web of Science databases. The article aims to identify the areas of research analysed in the literature concerning a smart city. This measure represents the first stage of the research process, aiming to identify the research problems in the field and a solution, which would constitute a theoretical and practical contribution to the development of smart city management.

All the considerations and research in the field of discussed issues are included in four chapters. The first chapter presents a general approach to the conditions of contemporary cities and presents smart city concepts. Next, the methodology used for bibliometric analysis is described. The third chapter is devoted to the results of the conducted bibliometric analysis. The last part of the work analyses the obtained results and presents the conclusions.

1. LITERATURE REVIEW

Intensive development, which is undoubtedly a challenge for modern cities, can give rise to positive outcomes for urban communities as well as negatively affect the smooth functioning of the city. The challenges of modern cities are centred around:

- uncontrolled urban sprawl (Kovács et al., 2019; Halmy, 2019; Yu et al., 2019; Mahmoud & Divigalpitaya, 2019);
 - environmental pollution (Caparros-Midwood et al., 2019; Alam et al., 2019; Munoz-Pandiella et al., 2018; Kosheleva et al., 2018);
 - urban logistics (Nataraj et al., 2019; Firdausiyah et al., 2019; Bjørgen et al., 2019; Cleophas et al., 2019; Faramehr et al., 2019; Mesjasz-Lech, 2014; Tomaszewska & Florea, 2018);
 - technical infrastructure (Petrova & Prodromidou, 2019; Faramehr et al., 2019; Pham & Phan, 2018; Juget & Ryckewaert, 2018);
 - waste management (Bugge et al., 2019; Amritha & Kumar, 2019; Dlamini et al., 2019; Scorțar et al., 2010);
 - aging population (Jayantha et al., 2018; Fang & Lai, 2018; Onoda, 2018; Greenfield, 2018; Jarocka & Wang, 2018);
 - stratification of wealth levels, areas of poverty (Muktiali, 2018; Lanjouw & Marra, 2018; Ma et al., 2018; Aguilar & López, 2016);
 - low level of citizen participation in the management of public affairs (Mavrodieva et al., 2019; Sou, 2019; van Holm, 2019; de Castro Pena et al., 2017).
- Knowing the identified challenges and the expected increase in the number of urban residents around the world, there is an increasing need for new and innovative ways to manage the complexity of urban life. In the last decade, the smart city concept has gained considerable popularity, ultimately enabling residents to better meet their housing, transport, energy and other infrastructure needs, but also as a key strategy to combat poverty and inequality, unemployment and energy management. The smart city concept assumes that a city should be a creative, sustainable area that improves the quality of life, creates a friendlier environment and the prospects of economic development are stronger (Lee et al., 2014). Intelligence as a distinguishing feature of this type of a city, should not be treated in the literal sense of the word but perceived as the sum of various improvements in urban infrastructure, resources and public services (Allwinkle & Cruickshank, 2011). Although there is no formal and widely accepted definition of a “smart city”, the ultimate goal is a better use of public resources, the improvement of the quality of services offered to citizens, while reducing operational costs of public administration (Zanella et al., 2014). It is understood that cities can be defined as smart if they have the following elements (Fig. 1).

The smart economy is measured by entrepreneurship and a city's productivity, adaptation to changes, the flexibility of the labour market and

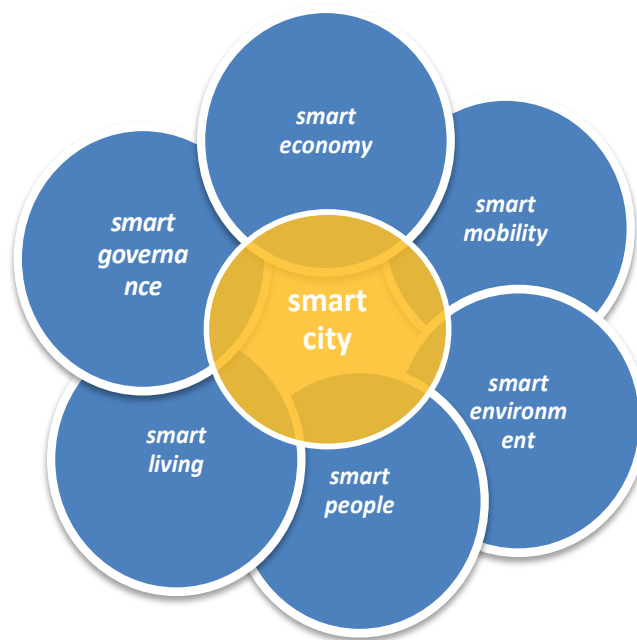


Fig. 1. Smart city elements

Source: elaborated by the authors based on (Stawasz & Sikora-Fernandez, 2016; Zanella et al., 2014; Caragliu et al., 2011).

international cooperation. Smart mobility is perceived by the accessibility of information and communication infrastructure, through the development of sustainable, innovative and safe transport. The smart environment is measured by the attractiveness of the natural environment, pollution levels, environmental protection activities and resource management methods.

Smart people are characterised by the level of qualifications, lifelong learning, social and ethnic diversity, creativity, openness and participation in public life. Smart living is measured by existing cultural facilities, living conditions (health, safety, housing), educational facilities, tourist attractiveness and social cohesion. Smart governance is expressed by the transparency of city management, social participation, the level of public services and the implementation of development strategies (Stawasz & Sikora-Fernandez, 2016; Zanella et al., 2014; Caragliu et al., 2011).

Many authors have attempted to formulate the definition of a “smart city” by binding it with different terms, which is indicative of the lack of a uniform or widely accepted definition (Schaffers et al., 2012; Zhuhadat et al., 2017; Chong et al., 2018). In publications dealing with the subject of a “smart city”, there are many alternative terms for this concept, such as: “digital city” (Tan, 1999), “wired city” (Targowski, 1990), “information city” (Fietkiewicz et al., 2017;

Sproull & Patterson, 2004; Stolfi & Sussman, 2001), “ubiquitous city” (Shin, 2009), “sensing city” (Mone, 2015). When reviewing the literature, it was noticed that in the vast majority of publications, authors attempting to define the concept of a “smart city” focused on the technological aspect. For example, Peng, Nunes and Zheng (2017) defined a “smart city” as a city using a set of advanced technologies, such as wireless sensors, smart meters, intelligent vehicles, smartphones, mobile networks or data storage technologies. In turn, Guo et al. (2017) claimed that a “smart city” is urban development based on the integration of many information and communication technology (ICT) solutions to manage the city’s resources. These definitions of a “smart city” emphasise the role of technology. However, a city can hardly become smart because of technology alone (Nam & Pardo, 2014). Ortiz-Fournier et al. (2010) included citizens of smart cities in the definition of a “smart city”. The authors described a “smart city” in the context of its intelligent inhabitants, the quality of social interactions, and integration with public life. In the current perception of the “smart city” concept, there is a return to the needs and preferences of the inhabitants, which are the focus. Thus, technical solutions should serve their interests. Residents, their specific features and abilities are the basis of a modern city (Mizielińska-Chmielewska, 2018). As rightly noted by Noworól (2011), the local government

should base their activities on the value system and focus on creating a vision of the future of the city. Szołtysek and Otręba (2015) added that the efficient preparation and implementation of activities were closely related to the need to recognise the feelings and emotions of all groups of residents, which should serve as a basis for efficient city management programmes. Huang, Zhang and Wang (2017) also emphasised aspects of city management. They defined a city as smart if it was managed in intelligently, efficiently and sustainably. According to the assumptions of Manville et al. (2014), a “smart city” is a city where public issues are solved using ICT, with the involvement of various types of stakeholders working in partnership with the city authorities.

As noted by Molpeceres Arnáiz (2017), according to some business and political discourses, a smart city seems to be the city of the future. However, despite the numerous potential amenities of a “smart city” that cities could draw from, there are some barriers that make the implementation of this concept difficult (Dohler et al., 2011). Among the difficulties that arise when implementing the “smart city” concept, several stand out (Ravetz, 2017; Naphade et al., 2011; Krukowska, 2018; Proseedmag, 2017; What ..., 2018; Sikora-Fernandez, 2017; Bashynska & Dyskina, 2018):

- excessive concentration on investing in advanced technologies without the real perception of conflicts and problems in cities;
- the deployment of smart technologies in cities with complex social problems can exacerbate social inequalities through technical improvements;
- the lack of implemented solutions to use the local community to co-manage the city;
- the lack of a comprehensive view of cities considering the needs in all areas of their functioning;
- changes related to the introduction of the “smart city” concept, mainly including the technological aspect, may negatively affect the loss of the existing character and unique charm of some agglomerations, especially those valued due to their traditional character;
- the majority of investments in the development of the “smart city” concept focuses on creating new facilities instead of modernising the old ones;
- the development of smart city infrastructure requires huge investments, which are indirectly made by citizens, e.g. in the form of a higher tax rate;

- managing cities is a huge challenge and requires, above all, intelligence, responsibility, and reasonableness, which cannot be replaced by modern technologies and especially building cities from scratch. City innovation is not glass skyscrapers and cosmic architecture, but the creation of the best living and working conditions;
- incompetently or unknowingly used services by so-called digital illiterate people can cause much personal and systemic damage;
- cities equipped with modern technologies, e.g. housing or newly built, do not become an object of interest to the inhabitants due to high maintenance costs and lack of social relationships (e.g. Masdar city or Tianjin Eco-city built in nearby Beijing, where there are no schools, shops, transport to factories where people can work).

Complexity, diversity and uncertainty are the three key attributes of modern cities (Fernandez-Guell et al., 2016), which hinder the conceptual and technical progress in the implementation of a “smart city”. In fact, this concept evolves from the simple integration of technology in the city with the development of solutions for urban challenges in a mutually connected and synergistic way (Lombardi et al., 2012; Mattoni et al., 2015). Processes that support the development, changes and everyday functioning of cities are complex and urban environments should be perceived as such as well, namely, as complex social engineering systems (Elzen et al., 2004). Many publications indicate the need to develop an integrated and holistic approach to a “smart city” (Perboli et al., 2014; Gil-Garcia et al., 2015).

2. RESEARCH METHODS

Considering the nature of the publication, which is a review, a bibliometric analysis was used as a research method. The results obtained using the bibliometric analysis are usually presented in the form of a map showing relationships between individual elements (Gudanowska, 2015, 2017; Siderska & Jadaa, 2018; Szpilko, 2017).

Based on the bibliometric analysis, the assessment of the dynamics of interest in the “smart city” subject was made, which is reflected in the number of publications in Scopus and Web of Science databases in the period from January 2009 to May 2019. In the next step of the research, a bibliometric map was created using the mapping technique VOS — the visualisation of similarities. VOS aims to locate items in

a low-dimensional space in such a way that the distance between any two items reflects the similarity or relatedness of the items as accurately as possible (Eck & Waltman, 2011). The map was developed using the VOSviewer program, which is available from www.vosviewer.com. The created map is the reflection of the co-occurrence of words and their co-classification in publications. The size of the wheels on the map reflects the number of specific words, while the distance between the wheels depends on the number of coexistence (Halicka, 2017). The co-word analysis is based on counting the frequency of appearance in the analysed text, a few words. It allows identifying phrasemes or regularities in the coexistence of words. Co-occurrence words can signal the existence of sub-area research or identify guideline directions for further development of a given research area. Results of the co-classification analysis allow identifying the sub-areas of research both in one area, as well as in interdisciplinary fields (Dobrzyński et al., 2013). This method enabled the creation of six clusters — the sub-areas of research relating to “smart city” issues.

The basic source of data in a bibliometric analysis is bibliographic databases. A review of the publications was made in Scopus and Web of Science databases. The databases were selected because of their size and availability. In Scopus and Web of Science, it is possible to save data from bibliographic queries in the form of files that can then be directly developed using the bibliographic software VOSviewer. The formulation, based on which the database was searched, was “smart city”, including in article titles, abstracts and keywords.

3. RESEARCH RESULTS

The exploration of the Scopus database resulted in finding 15744 studies registered in the database, of which the largest part were (Fig. 2) conference papers (63.4%) and articles (24.5%). In the Web of Science, authors found 5151 publications, of which the largest part, similarly to Scopus, were (Fig. 3) conference papers (55.6%) and articles (41.2%).

The great majority of publications were created in China, the United States, India, Italy, the United Kingdom, Spain, Germany and France. Numerous publications also originated in the Russian Federation, Australia and Japan.

The next step was dedicated to the analysis of the interest in the subject matter over the years. The time frame of the analysed period covered the last ten years from January 2009 to May 2019. The number of studies published in individual years is shown in Fig. 4.

Analysing Fig. 4, it can be noticed that initially — for the first five years — the interest in this subject was not significant. It is only since 2014 that interest in the “smart city” concept clearly increased, which is reflected by the number of publications in the Scopus database. Such dynamic growth in interest in this subject highlights the importance and validity of the subject area. In the next step, the identified publications were analysed in terms of research areas (Figs. 5 and 6).

In the Scopus database, over 34% of publications related to computer science and almost 19% to engineering. In the Web of Science, 37% relate to com-

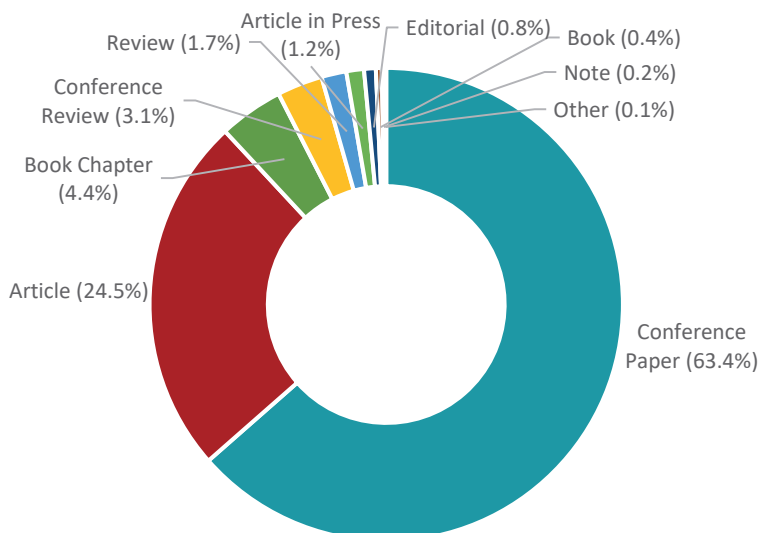


Fig. 2. Results of the search in the Scopus database — the document type criterion (indexed from January 2009 to May 2019)

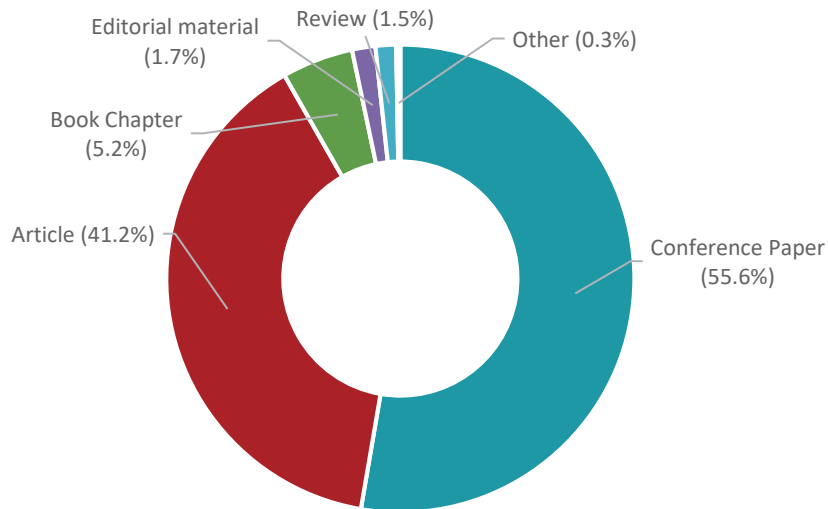


Fig. 3. Results of the search in the Web of Science database — the document type criterion (indexed from January 2009 to May 2019)

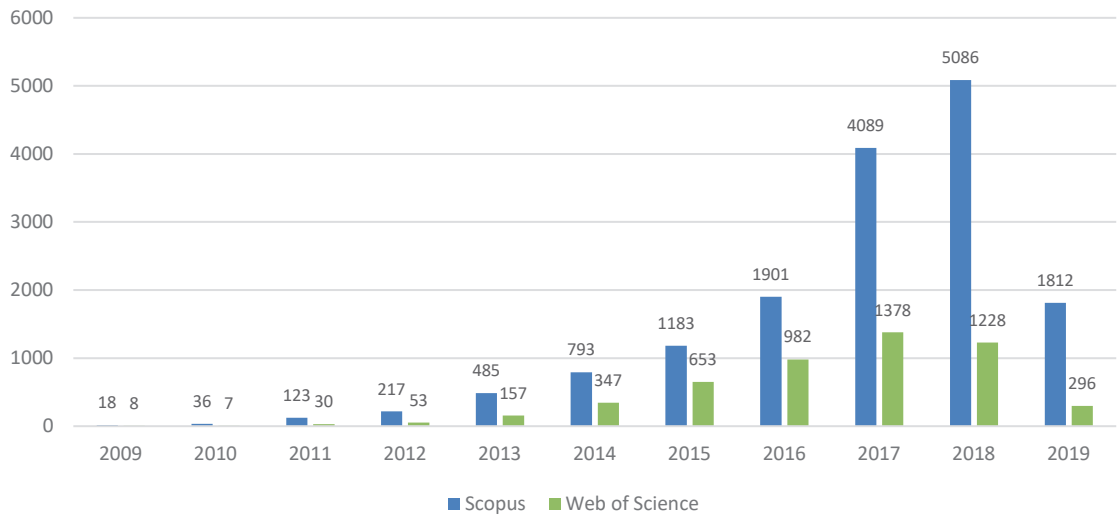


Fig. 4. Number of publications in the field of “smart city” in Scopus and Web of Science databases (indexed from January 2009 to May 2019)

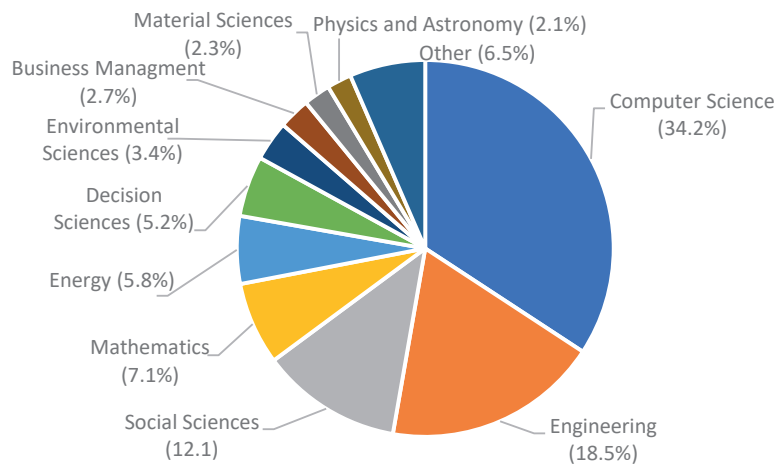


Fig. 5. Identified publications in terms of a subject area (Scopus database, indexed from January 2009 to May 2019)

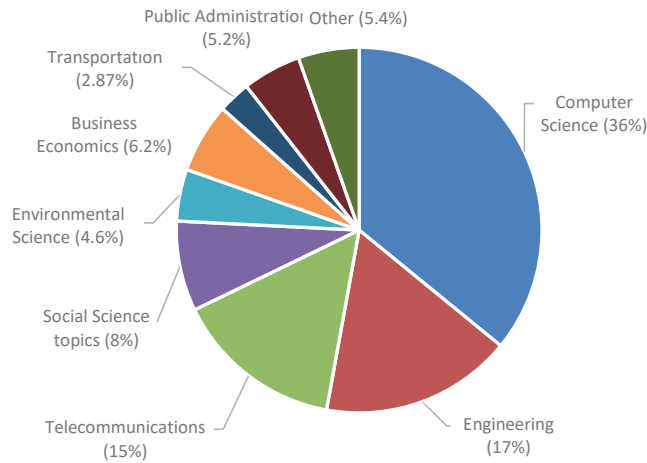


Fig. 6. Identified publications in terms of a subject area (Web of Science database, indexed from January 2009 to May 2019)

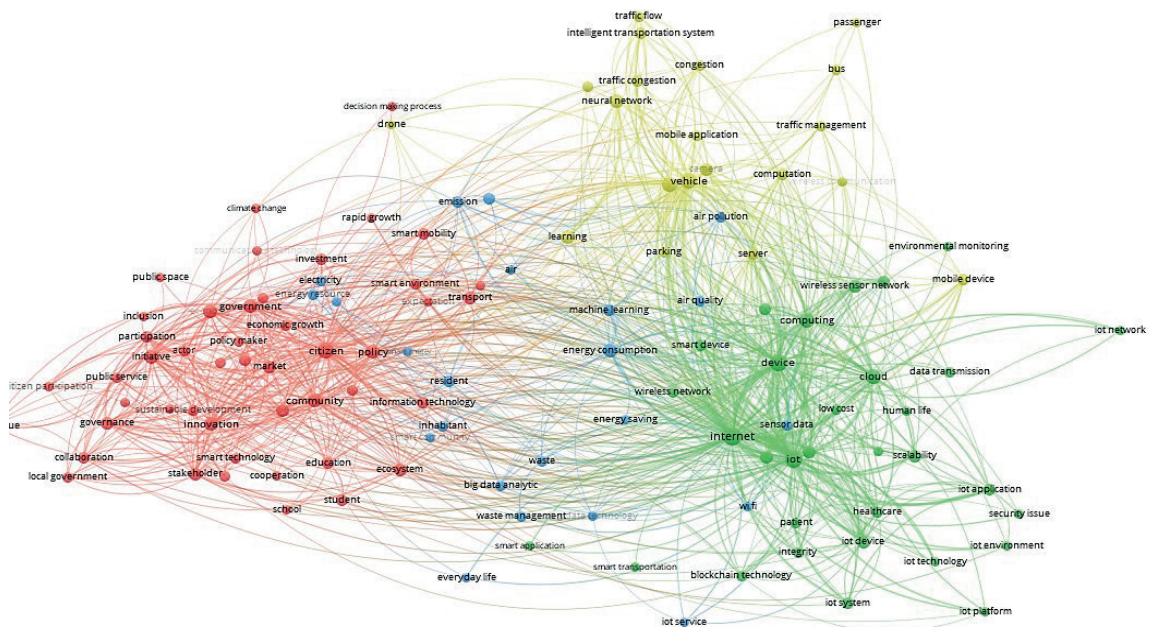


Fig. 7. Map of sub-areas related to the “smart city” concept

puter science and 30% to engineering. This proves that in most publications, the authors focus on technological aspects, where urban development is based on many IT solutions to manage the city’s resources. However, more and more authors, namely, 12.1% (Scopus), indicate the importance of social aspects in the smart city concept.

In the last stage of the bibliometric analysis, a bibliometric map was developed, which is a visualisation of the results of the analysis regarding the coexistence of words using the VOSviewer software. The results of the analysis are presented in Fig. 7.

The analysis of the coexistence of words made it possible to distinguish six clusters as sub-areas related

to the “smart city” concept. When analysing individual clusters, the following names were proposed:

- Cluster 1 — smart technology;
- Cluster 2 — socio-economic aspects;
- Cluster 3 — environmental aspects;
- Cluster 4 — urban logistics.

4. DISCUSSION OF THE RESULTS

By making a bibliometric analysis of the smart city concept, a very dynamic increase in the interest of researchers in this field over the last five years has been noticed. The areas addressed by authors in their publications were computer science and engineering.

Tab. 1. Sub-areas and main issues of smart city research

CLUSTER	RESEARCH SUB-AREAS	MAIN RESEARCH ISSUES
1.	SOCIO-ECONOMIC ASPECTS	<ul style="list-style-type: none"> the quality of social interaction (Neuroni et al., 2019; Tenney et al., 2019; Timmerman et al., 2019; Adnan et al., 2018; Vhaduri et al., 2018; Oliveira & Santos, 2018); the engagement of citizens in public life and decision-making; the participation of local stakeholders in managing public affairs; the collaboration between the local government and residents (Novo Vázquez & Vicente, 2019; Certomà & Rizzi, 2017; Streitz, 2017; Morgado et al., 2015; Ma & Lam, 2019; Horgan & Dimitrijević, 2019; Trencher, 2019; Manchester & Cope, 2019; Kundu, 2019; Mannan & Callenes-Sloan, 2019); healthcare (Sittón-Candanedo et al., 2019; Kumar et al., 2019; Kamel Boulos et al., 2019; Sedighian 2019; Chondrogiannis et al., 2019; Julian & Botti, 2019); security issues (Mattos et al., 2019; Krämer et al., 2019; Sittón-Candanedo et al., 2019; Sharma & Kalra, 2019; Xie & Hwang, 2019; Vitunskaitė et al., 2019); education (Sodiq et al., 2019; Fernández et al., 2019; Panchanathan et al., 2019; Safullin et al., 2019; Deng, 2019; Li, 2019); the development of entrepreneurship (Grimaldi et al., 2019; Gonzaga, 2019; Perng et al., 2018; Tay et al., 2018; Indravati et al., 2018; Carè et al., 2018);
2.	URBAN LOGISTICS	<ul style="list-style-type: none"> congestion (Zhao et al., 2019; Zhu & Liang, 2019; Yang & Zhu, 2019; Mishra, 2019; Reddy & Mehta, 2019; Garg et al., 2019); traffic flow management (Zheng et al., 2019; Ferrer et al., 2019; Vranken et al., 2019; Vaida & Mouftah, 2019; Chen, 2019; Kuang et al., 2019); autonomous vehicles (Li et al., 2019; Cantas et al., 2019; Schmitt et al., 2019; Ji et al., 2019; Xie et al., 2019);
3.	ENVIRONMENTAL ASPECTS	<ul style="list-style-type: none"> incorporating sustainable development principles into the smart city concept (Bibri, 2019; Ismagilova et al., 2019; Allam & Dhunny, 2019; Zhang & Pu, 2019; Cao et al., 2019; Chakraborty, 2019);
4.	SMART TECHNOLOGY	<ul style="list-style-type: none"> IOT — the Internet of things (Mattos et al., 2019; Sittón-Candanedo et al., 2019; Heaton & Parlikad, 2019; Jan et al., 2019; Rath & Pattanayak, 2019); cloud computing (Azhdari et al., 2019; Huang et al., 2019; Min-Allah et al., 2019; Wang et al., 2019; Del Esposte et al., 2019); big data (Kong et al., 2019; Putra et al., 2019; Lakshmanaprabu et al., 2019; Luo et al., 2019; Ameer et al., 2019); artificial intelligence (Khadse et al., 2019; Marcuzzi & Tonello, 2019; Wei et al., 2019; Panchamathan et al., 2019; Bui & Jung, 2019; Hu & Jiang, 2019); wireless sensor networks (Sadeghpour et al., 2019; Chammas et al., 2019; Godoi et al., 2019; Alduais et al., 2019; Marrero et al., 2019; Alchihabi et al., 2019; Sedighian & Kashi, 2019)

This proves that in most publications, authors focused on technological aspects, where urban development was based on the integration of many IT solutions aiming to manage the city's resources. However, more and more authors in their publications indicated the importance of social aspects in the smart city concept. The analysis of the co-occurrence and co-classification of words made it possible to identify four clusters that constitute research sub-areas in the context of the smart city concept. In Tab. 1, research sub-areas of the smart city concept are indicated as well as related emerging research directions and issues.

In the cluster defined as socio-economic aspects, there are elements such as the quality of social inter-

action and integration with public life. The important elements are living conditions, for example, health-care, security and education. The basis of a “smart city” is residents and their needs. In this cluster, the role of inhabitants and local stakeholders stands out, meaning their participation in managing public affairs and decisions making processes. There is a strong need for creating transparent principles of collaboration between local government and residents. Also, no smart city is possible without the well-prospering economy. The key is to develop entrepreneurship and business that would not only function on the local market but internationally as well. Another research sub-area concerns environ-

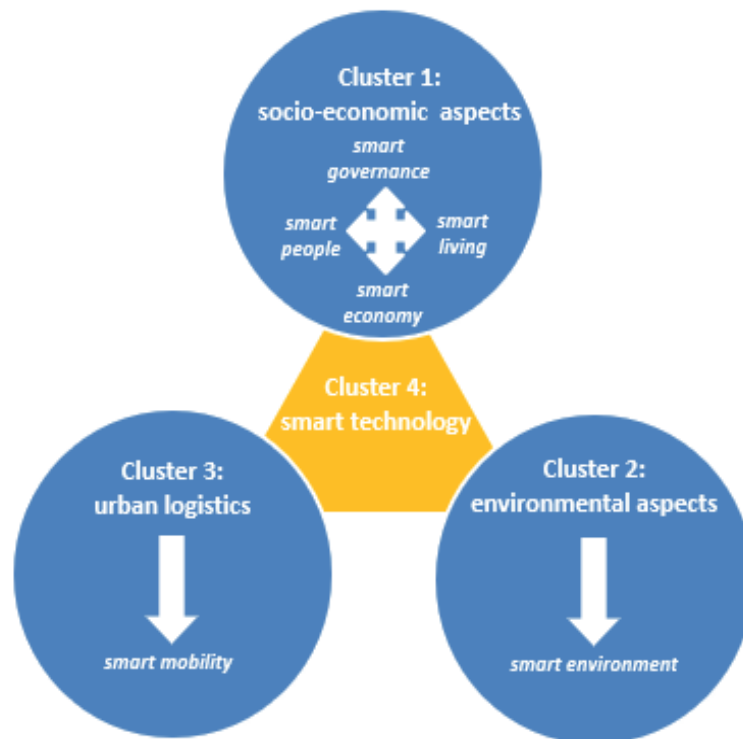


Fig. 8. Identified subareas related to smart city elements

mental aspects. A city cannot be named smart if it has no activities in the field of environmental protection and resource management methods. The care for the quality of the natural environment is of utmost importance, for example, by reducing emissions, pollution and using renewable energy sources. Generally, the principles of sustainable development should be followed. Analysing the third cluster, it can be noticed that the subject of urban logistics plays an important role in the smart city concept. In this context, urban logistics should primarily focus on planning, coordination and controlling processes related to a city or urban agglomeration, moving people and goods in a way that optimises costs, minimises congestion and improves the quality of life of the residents. The analysis of individual clusters revealed that the identified sub-areas could be related to the key elements required for a city to be called smart (Fig. 8).

Cluster 4 — smart technology — refers to a set of advanced technologies used in cities, such as wireless sensor networks, IOT, big data, cloud computing, artificial intelligence, applications, systems, mobile devices, mobile applications, wireless smartphones. The smart technology refers to each of the smart city elements. However, based on conclusions learned from the literature review and the previous difficulties in implementing the smart city concept, the real needs of people should always be placed first, and all

aspects of its surroundings should be considered. The smart technology is not in the centre but is a specific background for other elements. It is a tool for achieving goals, not an end in itself. Each of the elements of the smart city concept is a wide field of research. However, it should be remembered that they constitute one integral and inseparable whole, and they should be treated as such in the practical context. For a city to be described as smart, it must have all these elements.

CONCLUSIONS

A smart city is a relatively new concept. The dynamic development of innovative technologies provides opportunities to build smart cities. However, as demonstrated by the literature review, excessive focus on the technological aspect alone leads to many problems in the implementation of the smart city concept. A city can hardly become smart only by using technology. In the current perception of the “smart city” concept, there is a return to the needs and preferences of the inhabitants. They are the focus, and technical solutions are to serve their interests.

The bibliometric map created for this publication allowed identifying six sub-areas of research related to the smart city concept. While analysing the indi-

vidual clusters, it was noticed that they fit into the necessary elements of the smart city concept. For a city to be really smart, it must integrate such elements as the smart economy, smart people, smart living, the smart environment, the smart governance and smart mobility.

The literature review identified a research gap, which shows that the implementation of the smart city concept is poorly embedded in a multi-sphere and multi-variant vision of the future. In the opinion of the authors, a tool that would enable the development of a vision of the future of a smart city with the involvement of a wide range of stakeholders forming a local community, could be foresight, which has been successfully used in building a vision of the future of countries, regions and businesses (Nazarko, 2013; Nazarko et al. 2013, 2015a, 2015b; Ejdy, 2014; Szpilko 2015; Ejdy et al., 2019). It, therefore, seems appropriate to develop a foresight methodology for planning the future of smart cities, in which citizens are both users and co-creators of smart cities. To develop the methodology of creating smart city development based on foresight studies, research in this field of science will be continued by the authors.

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